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ABSTRACT

The Technical Education Research Center-SW has conceived, tested, and refined a model for disseminating newly developed programs and materials throughout the nation. The model performed successfully in the dissemination of more than 50,000 educational units (modules) of Laser/Electro-Optics Technician (LEOT) materials during a four-year period (1974 through 1977). The model assumes suitable materials and needs assessment data inputs from a materials development project. The materials are given visibility to educators and employers through no-cost/low-cost channels; target areas of high LEOT employment are identified; state and regional meetings are organized for representatives of interested institutions and employers; and organizations are selected (by consensus) for implementing new LEOT training or retraining programs. These materials users are assisted in program implementation and evaluation. (The appendices contain [1] the LEOT curriculum guide, [2] the LEOT instructional materials and program pamphlet, [3] the sample module from the LEOT curriculum, [4] mail-out materials from the LEOT announcement, [5] major activities of the dissemination project, [6] example correspondence, and [7] the LEOT modules/ways and means.) (Author/CSS)

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FINAL REPORT

PROJECT NO. 489AH50118

GRANT NO. G00-75-00314

A DISSEMINATION MODEL
FOR NEW TECHNICAL EDUCATION
PROGRAMS

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ABSTRACT

A DISSEMINATION MODEL FOR NEW TECHNICAL EDUCATION PROGRAMS (Project No. 489AH50118 performed under HEW Office of Education Grant No. G00-75-00314) was developed, tested and revised by Technical Education Research Center-Southwest. The model performed successfully in the dissemination of more than 50,000 educational units (modules) of Laser/Electro-Optics Technician (LEOT) materials during a 4-year period (1974 through 1977) - the grant covered only a 2-year period (May 1, 1975 through April 30, 1977), but dissemination began prior to this period and continued afterward. The model assumes suitable materials and needs-assessment data inputs from a materials development project. The materials are given visibility to educators and employers through no-cost/low-cost channels; target areas of high LEOT employment are identified; state and regional meetings are organized for representatives of interested institutions and employers; organizations are selected (by consensus) for implementing new LEOT training or retraining programs. These materials users are assisted in program implementation and evaluation. Reproduced materials are made available to the users at nominal costs. This final report, available from the Office of Education and/or from normal Government document services, describes the project and fully explains the model, which offers applicability to technical educational materials that meet suitability criteria for dissemination.

FOREWORD

Educational and training programs in technical or occupational fields are the most rapidly growing areas of our educational system. New programs are required as emerging or changing technologies mature and demand well trained technicians. However, school administrators are often unaware of the needs, and even when they learn of them are reluctant to initiate programs without assistance in curriculum design, adequate instructional materials, laboratories and competent faculties.

Development of good curricula and instructional materials is a time consuming and costly endeavor. When a school or organization accomplishes this task there is seldom any effort to disseminate the results and products to other institutions; thus the costly process is repeated many times.

Technical Education Research Center-SW has conceived, tested and refined a model for disseminating newly developed programs and materials throughout the nation, wherever they are needed. The model includes an evaluation criteria for the newly developed products; methods, organizations and interactive networks for effective program dissemination; and time and cost estimates to accomplish the tasks. This report is prepared as a guide for disseminating organizations and a reference document for future planning by the Office of Education program staff.

The project benefitted considerably from the advice and guidance of the National Industrial Advisory Committee for Laser Technician Training. The 19 members of this committee, whose time and travel were donated by their employers, are listed on page 21. Valuable assistance was also provided by the original pilot institution, Texas State Technical Institute, Dr. M. W. Roney, President and Mr. Johnny Jones, Chairman of the Laser Department. Key TERC-SW personnel who contributed to the project are Mr. James R. Johnson, Ms. Jean Forcher and Dr. L. Allen Parker.

This research was performed under a Grant (# G00-75-00314) from the U. S. Office of Education, Bureau of Adult and Occupational Education, Dr. Glenn C. Boerrigter, Contract Officer and Ms. Frances Hamilton, Project Officer. The project benefitted considerably from the guidance, advice and encouragement of Dr. Walter J. Brooking, USOE technical staff.

Dan M. Hull
Project Director

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SECTION I

INTRODUCTION

Through the years, educators and technological experts have collaborated to produce educational curricula and supporting instructional materials. Such efforts, usually expended within a single institution or organization, seldom have led to replications in other schools or industrial training programs. In fact, unless profitably attractive to publishers (for distribution through established textbook channels) such educational materials are apt to exist only on the shelves of developing organizations.

This pattern especially prevails whenever educators, institutions and employers are engaged in the training of technicians for limited or emerging technical occupations. Thus, there exists throughout America a myriad of duplications of effort in curriculum development, leading to needless expenditures of time and money and, frequently, to instructional programs with substandard quality and irrelevant content.

Several reasons can be cited as to why a school or training program does not adopt materials and program content developed by another institution or organization; for example:

- They are not aware that such materials exist - no visibility.
- They are not convinced that such a program is needed in their locale.
- They are unable to adapt the (too-specialized curricula or instructional materials to their needs - material is not adaptable (is not modular) for local needs.
- They require 1) counsel from the developer and 2) a pilot program to model in setting up a program.
- The instructional materials are not available from a central source (and have not been kept up to date).

DISSEMINATION NEED

Dissemination of new technical programs includes those activities (performed by the curriculum developer or a third party)

that result in the newly designed curricula and supporting instructional materials being adopted and used in various educational environments, wherever they are needed. The typical pattern of activities for research and curriculum development in emerging technical occupations is shown in Figure 1. The last activity - dissemination - has remained somewhat nebulous, seldom funded or supported, and never explicitly defined.

Dissemination, then, has been a passive ideology. Developers and sponsors have assumed that if such products were catalogued filed in a central clearing house, and announced, then institutions and training organizations would somehow find them and be enthusiastic about using them. But this utopian concept has seldom, if ever, been realized.

Dissemination, to be successful, must be a positive, deliberate action, carefully planned and considered from the outset of the initial research and development. It should be funded by the curriculum-development sponsor to ensure cost-effective utilization of the development project's products.

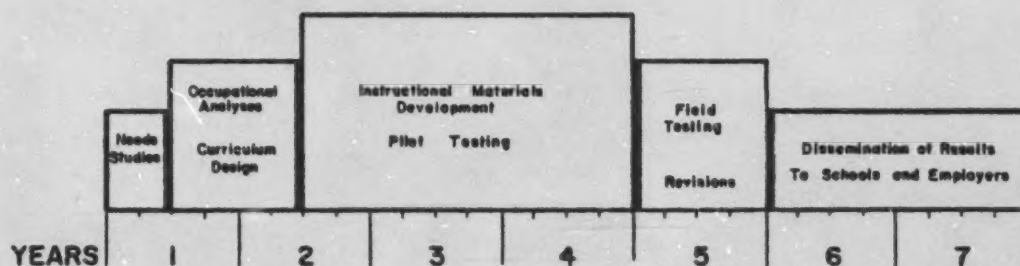
Also, dissemination activities should consider that a large part of the educational needs generated by an emerging technology consists of retraining already employed personnel, either in institutions, in employer training programs or in short courses and seminars.

To extend this line of thinking a step further, dissemination is an attitude, strongly entrenched in the minds and goals of the research and development staff. Dissemination activities should be pursued early in the project whenever the opportunity presents itself.

DISSEMINATION MODEL DEVELOPMENT

In 1975, Technical Education Research Center - Southwest (TERC-SW) proposed to develop a model for dissemination of new technical education programs, which included the following elements:

- Flexible curricula, with options.
- Modular instructional materials.
- Third party disseminator.
- Network of employers to provide counsel, visibility and assistance.



Needs Assessment - to determine how many employees will be needed over the next ten years, the geographic distribution of these needs, identify or structure job categories, and delineate the training needs according to preparing new employees or retraining an existing workforce.

Occupational Analyses/Curriculum Design - to determine the specific tasks which the technician will be required to perform upon entering a job and the technical fundamentals which he needs to understand why and how to accomplish present tasks and advance in future assignments.

Instructional Materials Development/Pilot Testing - to prepare relevant, flexible instructional materials which are modular and can be adapted to a variety of learning environments and curricula. Each module is oriented toward "hands-on" learning and is based on specific training objectives derived from the task analysis. The materials are tested in actual pilot class/labs at a selected school.

Field Testing/Revisions - to validate the educational effectiveness of the materials in controlled classes. This is accomplished by schools which have initiated the program, and collect data on student performance for each educational objective.

Dissemination of Results to Schools and Employers - to assist training organizations in determining the need for the program in a local area, designing the curriculum, and securing equipment, labs, faculty, students and jobs.

Figure 1. Educational research and development for emerging and changing technical occupations - Present Funding Patterns.

- Strategy for identifying target areas for new programs and methods and procedures for selectively assisting and encouraging organizations and institutions to implement them. (Figure 2).
- Estimate of the time and money required to implement model activities.

To test the proposed model, TERC-SW undertook dissemination on a nationwide basis, of the recently developed and tested Laser/Electro-Optics Technology curriculum. This curriculum included a Curriculum Guide (including an equipment list) and 102 modules of instructional materials, developed and pilot tested in a project completed in December, 1974.

In July 1975, a grant to test this dissemination model was awarded by the U. S. Office of Education, Bureau of Adult and Occupational Education. The grant was originally awarded for an 18-month period, but was later extended, at no additional cost, to 24 months.

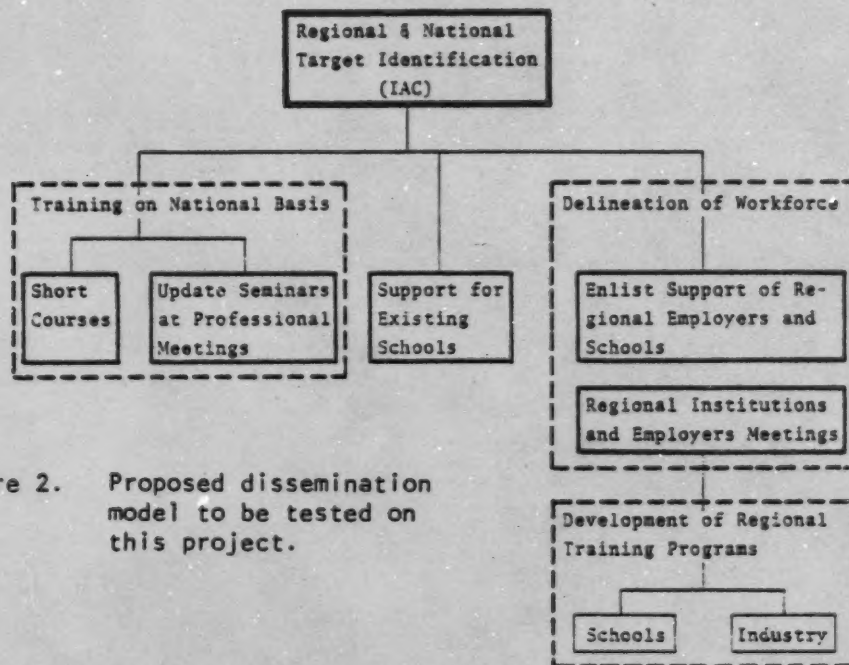


Figure 2. Proposed dissemination model to be tested on this project.

This report describes 1) the proposed model, 2) a review of activities undertaken to test the model, 3) an evaluation of the results of these activities, 4) a revised model and 5) a summation, which incorporates conclusions deduced from the project and recommendations that logically evolve from the conclusions.

SUMMARY OF RESULTS

To date, more than 50,000 copies of LEOT modules have been used in various instructional environments; about half of which were used to prepare new technician employees, with the other half used to retrain existing employees.

At the completion of the development project (December 1974) more than 7000 copies of LEOT modules had been used as follows:

- Four schools preparing new LEOT employees.
- Four inhouse, company-sponsored courses to retrain employees.
- Three, five-day short courses for retraining technicians and engineers.
- Two, one-day, professional advancement courses.
- Other uses (e.g., laboratory manuals for graduate science studies at universities).

As a direct result of dissemination effort expended in this project, utilization of modules increased significantly; the status of module usage, as of December 1977, is as follows:

- Thirteen schools are preparing new LEOT employees (Each school has expended an average capital investment of \$140,000 and has an annual operating cost for its program estimated at \$60,000).
- Twenty-three inhouse, company-sponsored courses have been conducted to retrain employees.
- Twenty-five, five-day short courses have been conducted for retraining technicians and engineers (more than 300 attendees).
- Six, one-day professional advancement courses provided by societies at national meetings (more than 300 attendees).
- Other uses (such as seminars on the use of lasers in building construction).

The model presented in Section IV of this report differs from the preliminary model, in detail rather than concept, which suggests

that most of the planned approach worked to some extent. And the overall project, deemed successful in so far as LEOT was concerned, appears to have application to other educational programs and materials for limited and emerging technologies. Thus, the model developed as a result of this project, though in need of further field testing and corroboration, meets the "realizable" requisite of the project.

A key (indeed, critical) element of the model is the third party - an entity apart from the involved educators and employers, but keenly interested in all educational environments. This third party may be the curriculum/instructional material developer or it may be some other independent organization.

SECTION II

THIRD-PARTY (DISSEMINATOR) REQUISITE

As predicted in TERC's original proposal to develop a dissemination model, efforts by local institutions and employers to develop technical curricula inevitably precluded any potential for broad-based distribution of their materials. At the same time, a prima facie case was established to substantiate the contention that successful dissemination of such materials required a third party, independent of both employers and educators, but highly attuned to the needs of each.

This third party must assume responsibility for activities clearly outside the usual responsibilities of materials developers or users. Assuming that the instructional materials possess adequate disseminating qualities (i.e., modular, adaptable and relevant) the third party disseminator activities include:

Visibility Activities - Finding educators and employers at schools, technical organizations and professional societies with an interest in organizing and conducting local instructional programs.

Catalyst Activities - Bringing the interested parties (schools, societies and employers) together and encouraging them to implement local and national programs. Includes the conduct of regional or state needs surveys and development of job inventory specifications.

Program Support Activities - Providing assistance on a local basis to schools and employer training organizations that wish to implement programs - includes curricula design or adaptations, identification of local employers, design of laboratories, selection of lab equipment and teacher training.

Revising, Publishing and Distributing Activities - Up-dating and volume reproduction of instructional materials; shipping and coordinating materials distribution.

Since TERC-SW developed the LEOT materials used in this dissemination model, most of the activities mentioned above began during the development phase, as they ideally should. However, it is conceivable that the disseminating activities could be continued after development by a party other than the developer of the materials.

SECTION III

METHODOLOGY

The approach to implementing a realizable dissemination model onto the LEOT materials was dictated to some extent by the nature of the materials, the status of the technology and the timeliness of the project. (In later discussions, efforts are made to adjust the model to be functional in more general circumstances.)

EVALUATION OF INSTRUCTIONAL MATERIALS FOR DISSEMINATION QUALITY

Certain characteristics inherent in a material enhance its potential for dissemination. To best employ the revised dissemination model, material should meet four criteria:

Be Modular in General Design - Modular (one relatively free-standing unit limited to a single concept or idea) materials exhibit the necessary flexibility for diversification of application in a variety of educational environments in career education.

Relatively independent modules of instruction allow an instructor (aided by a local task inventory) to choose from a "shopping list" of topics, and rearrange or build curricula and course content to meet the needs of employers served and fit within the resources of the institution.

The modular aspect of the material also enables it to be adapted for use in seminars, short courses, correspondence courses, extension courses, and employer-sponsored courses - for retraining employed adults. (See "Adaptibility Through Modular Instructional Materials," Appendix G.)

Materials also must be relevant (current), job-related and valid. Based on job specifications derived from a consensus of national employers and advisors, LEOT jobs vary greatly, from equipment assembly to medical technology applications, which means that the training materials must relate to a broad spectrum of jobs. Similarly, teaching situations demand materials validity from an educator's standpoint. (The criteria for

this latter requirement are far from being clearly defined, especially within the domain of emerging technologies.)

Be Relevant to Current Employer Needs or Job Specifications - Materials must be up to date, technically accurate and job related. To ensure that the materials are job related, the curriculum developer must have devised his module objectives from job specifications and task inventories. To verify that the materials are accurate, current and job related, a large number of copies (at least 25) of the modules should be distributed to employers and technical specialists for review and comment prior to the developer making final revisions.

Be Understandable and Effective in the Eyes of the Students and Educators - As a minimum, the materials should have been used in a pilot program at an educational institution, with comments received from students on their ability to read and understand the material, and comments received from faculty on problems encountered while trying to use it. Each module objective should be evaluated (pre and post test) to measure the percent of learning gain by a sample of students. All comments, as well as reviews from educators, should have been used in final revisions by the curriculum developer.

Rigorous field tests on materials used in programs for new and emerging technologies are difficult to conduct and even more difficult to interpret. Furthermore, the value of this type of data in establishing credibility of material to educators is questionable, as evidenced by the fact that, with more than 50,000 LEOT modules sold over a four year period, not a single buyer asked for field-test data.

Be Supplemented by Curriculum Support Documents - For example:

- Curriculum Planning Guide (including regional list of employers and equipment list.)

As a minimum the curriculum planning guide should justify the curriculum, describe it and provide step-by-step procedures for implementing it. For

LEOT, a comprehensive but simplified guide greatly enhanced dissemination efforts: a copy of this guide is enclosed (Appendix A) to provide a model for subsequent projects.

- Curriculum description brochure or pamphlet.

A guide may be too expensive to mail out in response to all inquiries for information; therefore a simple, attractive pamphlet or brochure should be offered initially. If properly prepared, this document can fulfill both the merchandising and information disseminating functions. Documents used in the LEOT project are enclosed also (Appendix B).

Additional documentation should include selected samples from the curriculum materials, such as the LEOT Course I, Module 10 (Appendix C), of which 3000 copies were distributed. Also dissemination may require thousands of letters, such as prospecting letters (forwarded to school administrators and teachers, as well as present and potential employers) and responses to inquiries from prospective users of the materials. As will be noted later, the wording and content of these letters plays a significant role in the success of a dissemination program.

Effective correspondence comes into play in at least one other way. If the materials developer has done a thorough job, a work-force needs assessment on at least a regional basis (if not a national one) will have been completed. For LEOT, the assessment was regional, but with national implications. (Unfortunately, however, most curriculum development projects for limited or emerging technology applications rest upon local needs with only speculative potential for greater implication.) If the assessment data provided by the materials developer falls short of dissemination project minimum requirements, additional work must be conducted as a part of (and prerequisite to) the actual dissemination. (How this work, which involved prolific correspondence, was incorporated into the LEOT dissemination project, and subsequently, into the dissemination model is described in Section IV.)

Certain activities inherent in curriculum development may be significant dissemination activities also. For example, judicious selection of an industrial advisory committee for curriculum development, utilizing employers in the specific technology, should lead to open dissemination channels: An enthusiastic committee member is apt to be an enthusiastic supporter of the course in his or her affiliated institution or industry or geographic area.

Thus, the materials developer's overall plan should anticipate dissemination requirements, as touched upon here, and as mentioned previously with reference to flexibility, relevancy and validity. All of which contributes to the usability and visibility of educational materials.

VISIBILITY ACTIVITIES

The best materials may lie dormant unless potential users know of their existence. How to spread the news as to the existence of curriculum materials for limited and emerging technologies poses the central question associated with dissemination. Generally the elaborate advertising and merchandising opportunities available to textbook publishers are closed to the dissemination of these materials which are more specialized and would probably have a relatively low demand.

For the most part, visibility of LEOT materials seemed to be dependent upon four relatively inexpensive approaches:

- Professional contacts (formal and informal).
- Correspondence with school administrators, teachers and state directors.
- Articles and news releases.
- Audio and audio-visual presentations.

Again, a properly selected industrial advisory committee (comprised of employers, potential employers and training personnel from industry and administrators and faculty from educational institutions) plays an invaluable role in dissemination, as does a successful field-evaluation or pilot test program. If a practical solution to an obvious problem exists, word of its existence and source can be spread rapidly through the efforts of concerned professionals, especially those who are members of an active national industrial advisory committee.

Direct mail may be second in effectiveness only to direct contact in a dissemination effort. In the LEOT dissemination project, one mail campaign proved highly successful while a second elicited only two positive responses. These efforts are evaluated elsewhere.

For the most part, journalistic effort in the LEOT dissemination project was addressed to the industrial/employer reader, to the partial exclusion of the educators. Insofar as it went, the effort elicited a high level of response.

Heavy emphasis on visibility to employers outweighed exposure to educators in the LEOT dissemination project, which was later recognized as a procedural error. In the final evaluations, adjustment of this imbalance produced a more generalizable model.

Such presentations as papers to conferences of societies and associations served effectively to establish and disseminate a positive image of the LEOT materials. For example, on March 24-26, 1977, in Memphis, Mr. Dan Hull addressed the National Clinic on Technical Education on Technical Education (co-sponsored by the U. S. Office of Education, American Technical Education Association and American Vocational Association), abliquely mentioning the laser/electro-optics technician training materials. Positive responses and inquiries were generated.

Other papers and presentations have dealt directly with LEOT with even more favorable responses. No formal tapes, film strips or slide presentations have been developed, however, for purely dissemination use. Such materials seemed less personal, less versatile and more expensive than the approaches used.

At the onset of this contract, certain visibility measures were already underway - the purpose of the contract being more to validate the model already conceptualized and in progress than to fund all phases of the dissemination.

The LEOT development project Final Report (dated January 1975) delineates dissemination activities completed or begun as a function of the materials development project.

- Very early in the project, attempts were made to alert those in the technology and in schools that programs soon would be available. (Table 1 lists articles in newspapers, magazines, journals and books describing the LEOT project and/or the pilot program.
- As schools and industry learned about the activities, TERC-SW began working with them, supplying them with draft copies of curriculum and instructional modules. When it seemed appropriate, the Project Manager would visit institutions to assist them in planning. As early as 1973, TERC-SW taught a short course for an organization where a large number of LEO technicians worked.
- The curricula and the instructional materials for the LEOT project were designed for maximum flexibility so that local educational institutions

TABLE 1

Articles appearing in newspapers, magazines, journals and books (from materials development final report).

1. Albertson, L. "School of Skills". The Texas Star. April 2, 1972. pp. 8-13.
2. Doss, C. B., and J. D. Pierson. "The Laser/Electro-Optics Program at Texas State Technical Institute". Technical Education Yearbook 1973-74. pp. 51-54.
3. Editor: "First Student Chapter Formed at Texas State Technical Institute". Lasersphere.
4. News Article: "Laser Evaluation Team Studying TSTI Program". Valley Morning Star. Harlingen, TX December 10, 1974.
5. Goldman, L. Applications of the Laser. CRC Press, 1974.
6. Gould, G. "Help Wanted: 100,000 Laser Technicians". Lasersphere. July 15, 1972. pp. 100-11.
7. Guenther, A. "Answering the Call for Trained Laser Electro-Optics Technicians". Laser Focus. June, 1973.
8. Hull, D. M., and others. "Adaptability Through Modular Instructional Materials". Technical Education Reporter. September - October, 1974. pp. 37-45.
9. Jones, J. "What Do You Do After You Purchase Your Laser?" Optical Spectra. November, 1974, p. 6.
10. Pierson, J. D., and D. M. Hull. "Laser/Electro-Optics and the Technicians Who Handle It". Industrial Education. December, 1974. pp. 42-44.
11. Rockwell, R. J. "Growth in Technical Training". Lasersphere. p. 15.
12. Rockwell, R. J. "The Laser/Electro-Optics Technician". Lasersphere. March 15, 1972. p. 9.

could implement programs that would more nearly meet local needs. This flexibility also gives the school administrators and faculty the opportunity to "invent it here."

- Examples of schools that have adapted the LEOT project materials to their local needs and capabilities include:

San Jose City College - Implemented an LEOT option to their existing program in Vacuum and Glassworking Technology. Graduates are particularly useful to gas laser manufacturers who are centralized in the San Francisco area.

Idaho State University - Implemented an LEOT option to an existing Electronics Technology.

Texas State Technical Institute, Harlingen, Texas - Implemented the Model Curriculum, including LEOT modules translated into Spanish/Bilingual versions.

The University of Illinois - Incorporated more than 30 modules into a graduate level, laboratory course for engineers, physicists and chemists.

- In September, 1973, a mail announcement consisting of a cover memo, a list of instructional modules and a reply form was sent out to approximately 2,200 schools (in the U.S.) that provided technical instruction (Appendix D). The reply form carried a "requested return date" of October 26, 1973. A second mailing went out in November (1973) to those schools not responding to the initial effort. (Through December, 1973, replies received from 717 schools represented a 33% response. Approximately 23%, or 494 schools, requested additional information.)

Also, in August, 1974, a workshop for interested administrators and faculty attracted 22 participants. Previously, in July, 1973, TERC-SW had conducted a one-week short course in lasers for the engineers and technicians of the Lawrence Livermore Laboratories (Livermore, California).

Since 1972, the University of Cincinnati has used LEOT modules in their laser safety short course. In August, 1974, they, along with TERC-SW and the Laser Institute of America jointly sponsored a one-week short course, "Introduction to Lasers," based on the content of Course I of the LEOT modules.

In November, 1974, four LEOT modules provided the content of a one-day Professional Advancement Course presented by TERC-SW and instructional personnel of Texas State Technical Institute. This course met in concert with a joint meeting in San Francisco of the Laser Institute of America and the Society for Photo Instrumentation Engineers.

Also, in 1974, an attempt was made to enlist a publisher to reproduce and disseminate the LEOT materials. Only one bidder attended the bidders meeting held in November, and no bids were received. Follow-up inquiries indicated that the materials "lacked sufficient economic potential" to merit commercial consideration - not necessarily a valid conclusion, considering the quantity of material subsequently disseminated.

DISSEMINATION GRANT ACTIVITIES

The dissemination efforts begun early in the LEOT materials development project continued apace through the dissemination model development grant period. Mailings continued: technical education directors in all 50 State Educational Agencies were contacted (with minimal results, possibly attributable to the contents of the letters). The LEOT development project's national industrial advisory committee continued to provide intercourse between TERC-SW and institutional and industrial personnel. Similarly, concerned members of the related technical societies and professional associations created opportunities to expose the curricula materials. Thus, at the conclusion of the dissemination model development grant, use of the LEOT materials had attained an impressive level, as reflected in the following dissemination of modules:

1974	7,000.
1975	10,000.
1976	16,000.
1977	19,000.

(For a comprehensive discussion of the Major Activities of the Dissemination Project refer to Appendix E. These activities, though absolutely essential to the development of dissemination

data for both the project and the model, lend little if anything to the reader's understanding of the model, and the comprehensive discussion relates only incidentally to its application; therefore, this material appears in appended form.)

NEEDS ASSESSMENT SURVEY ELEMENTS

The primary requirement for an effective survey, or needs assessment, appears to be selection of properly qualified people to serve on the industrial advisory committee from the earliest phase of materials development on through the critical phases of dissemination.

Selection of an industrial advisory committee for an educational materials development project often concentrates upon a single quality or characteristic (such as technical competence or prestigious standing in the technical community) but, in the long-run, other factors are equally significant. For instance, dedication, ability to make and keep commitments (both personal and corporate) and willingness as well as opportunity to influence appropriate educators and employers to make appropriate use of the materials. Competent, enthused and active committee members cannot help but play significant roles in any dissemination project. And, if the dissemination is to be geographically broad-based, their roles may be even more critical.

One essential ingredient of any materials development project is an adequate needs assessment - to what extent are personnel needed who have the skills or knowledge unique to (or uniquely presented in) the materials involved? If the materials are for local use only, the assessment need only reflect local needs. And both educators and employers tend to respond more favorably to a survey with a local flavor - a survey in which their inputs are apt to carry more weight.

Even so, the assessors in a survey, significant as they are, cannot be effective without an effective survey vehicle.

An effective needs assessment survey must be both quantitative and qualitative. Commercial application of a technology means jobs for people. Thus the purpose of a needs assessment survey is twofold:

- To determine the approximate number of jobs available at given times for technicians trained in the technology.

- To determine what new technicians need to know and will be expected to perform when they are hired.

The latter determination can be greatly compounded in certain technologies (such as LEOT) that enjoy a wide variety of applications and provide employment for technicians in such diverse occupations as super-market check out and energy research.

A third determination, equal in importance with the two listed above, assumes an even greater significance in the dissemination process - that third determinant is the geographic disposition of the jobs. Historically, technical training is most effectively offered in institutions circumjacent to employers of the technology. Three significant circumstances undergird this generalization.

First, an employer's requirements for technical employees are apt to be more widely known close to home and, therefore, awareness to these requirements are more likely to be manifested in local prospective students.

Second, employers of technical personnel are generally more interested in hiring from local colleges and institutions, reflecting both a civic and an economic response (no moving-expense outlay).

In fact, students frequently work and continue their technical education simultaneously if their particular technology is taught locally. Thus, the third significant circumstance is the requirement for continuing and cooperative education, which suggests a reasonable proximity between educator and employer.

With these circumstances in mind, the needs assessment survey must make geographic determinations nationally, but with emphasis on localized implications. Similarly, the assessment must provide data pinpointing commercial and/or industrial target areas.

An adequate needs assessment survey allows the dissemination project manager, supported by the industrial advisory committee to identify specific target areas and to assign priorities to these areas. For example, if - as with the LEOT project - a major concentration of employers of the technology is situated in the San Francisco Bay area, extensive dissemination effort should be concentrated in this area. With counseling, if not direct assistance, from the area industrial advisory committee member(s),

a Bay-area educator or employer should be targeted. Similarly, a second pocket of employers in Ohio might also receive concentrated effort from a dissemination team. And so on.

Meanwhile, schools across the nation offering related technical education, and employers and potential employers of the technology, should be informed of the existence of the materials as well as other aspects of the dissemination project.

In general, however, the "shotgun" approach to publicizing materials should be restricted to the journalistic opportunities discussed previously in this report. Targets, insofar as possible, should be specific and clearly defined.

As touched on above, not all technicians associated with a general technology perform the same tasks or require the same training in that technology. Table 2 lists many of the varied assignments from which a LEOT might reasonably expect to choose a career.

Other technologies may be equally as diverse, and all possibilities must be evaluated as a product of the assessment survey. Again, these discoveries, which should be made at the outset of a materials development program, often cannot be successfully accomplished at that time - there may be a lack of resources for a comprehensive survey, or the applications simply may not be readily identifiable. For example, only the strong industrial representation on the LEOT advisory committee (Table 3) allowed such thorough identification of the various kinds of LEO technicians in commercial and governmental employment.

This work, done early in the curriculum development project, obviated any extensive needs assessment activities as a part of the dissemination project. But not all. For one thing, several years elapsed between the initial survey (in 1971) and the mid-1975 beginning of the dissemination-model grant. Fortunately, the industrial advisory committee remained essentially intact and continued to be enthusiastically involved in the program. Thus - again with considerable support from the industrial advisory committee - the measures identified above were carried out thoroughly to ensure a proper survey instrument and activity for the model.

As a result of this thorough needs assessment survey, TERC-SW was able to design educational programs to meet the reasonable, current requirements of industry, using selected modules from the materials in their original formats.

TABLE 2

Many of the possible career opportunities
for a laser/electro-optics technician (LEOT).

Laser Science (or engineering) Technician - works under direction of scientist or engineer in research and/or in the development of lasers, optics, elector-optics and related systems, and in military and space labs.

Laser Engineering Applications Technician - incorporates lasers (as components) into systems such as radars, communications and telecommunications, and materials processors (e.g., welding, drilling and cutting machine).

Laser Systems Manufacturing Technician - fabricates and tests various laser and optical assemblies.

Laser Materials Processing Technician - processes laser materials (does welding, scribing, drilling, cutting, etching and surface treating; works for auto manufacturers, heavy equipment manufacturers, electronic component manufacturers and the like.

Guidance, Alignment and Construction Technician - uses lasers to align and guide instruments (such as cameras), component, systems and equipment (such as earth movers).

Civil Technician - uses lasers to make distance measurements (surveys).

Laser Medical Technician - repairs, maintains and calibrates laser instrumentation.

Laser Safety Officer - inspect laser installations for safety and compliance with local, state and federal regulations.

Laser Field (or service) Technician - uses, maintains, repairs, calibrates, performs acceptance tests and inspects lasers in a variety of applications including radar, communications, control, tracking product scanners, nuclear fusion, electronics, etc. (industry, military, space).

QA/QC Technician - performs nondestructive tests by using laser holography.

TABLE 3

The National Industrial Advisory Committee
membership roster (dissemination phase).

- Mr. Carl Bailey, Jr.
734 Michigan Avenue
Orlando FL 32806
305/423-5225
- Dr. H. S. Boyne
Electro Magnetic Division
National Bureau of Standards
Boulder, CO 80302
303/499-1000 X 4343
- Mr. Robert D. Compton, Editor
Electro-Optics Systems Design
222 West Adams Street
Chicago, Ill 60606
312/263-4866
- Mr. Dave Edmunds
Xerox Corporation
MS 147 Xerox Square
Rochester, NY 14644
716/422-6115
- * Dr. Arthur Guenther, Chief Scientist
Air Force Weapons Laboratory/CA
Kirtland Air Force Base
Albuquerque, NM 87117
505/264-8956
- * Mr. Dan M. Mull, General Manager
Technical Education Research Center-SW
4201 Lake Shore Drive, Suite 111
Waco, TX 76710
817/772-8756
- Mr. Bob Paugh
Spectra Physics
1250 West Middlefield Road
Mountainview, CA 94040
415/961-2650
- Mr. Richard Peterson, Chief
Laser Electro-Optics Branch
Bureau of Radiological Health
Food and Drug Administration (HEW)
5600 Fisher Lane
Rockville, MD 20869
301/443-2965
- * Dr. John D. Pierson
Instructional Personnel
Texas State Technical Institute
James Connally Campus
Waco, TX 76705
817/799-3611
- * Mr. John Reedy
Honeywell Corporate Research Center
10701 Lyndale Avenue South
Bloomington, MN 55420
611/887-4430
- * Mr. A. James Rockwell Jr.
6282 Coachlite Way
Cincinnati, OH 45243
513/281-3338
- Dr. M. W. Roney, President
Texas State Technical Institute
James Connally Campus
Waco, TX 76705
817/799-3611
- Mr. David H. Sliney
Laser-Microwave Division
US Army Environmental Hygiene Agency
Aberdeen Proving Ground, MD 21010
301/671-3932
- Dr. Donald Sims
HADRON
President Kored Division
2520 Colorado Avenue
Santa Monica, CA 90404
213/892-3377
- Mr. James F. Smith
IBM CORP, Dept 392/415
Poughkeepsie, NY 12502
914/463-1495
- * Mr. Robert A. Wallace
Research Physicist
American Optical Corporation
Department 4502 Building 51
Southbridge, MA 01550
617/765-9711 X2473
- Dr. David Whitehouse
Raytheon Company
Advanced Laser Development
130 Second Avenue
Waltham, MA 02154
617/890-8080
- Mr. D. C. Winburn
MS 625, P. O. Box 1663
Los Alamos Scientific Laboratories
Los Alamos, NM 87544
505/667-5898
- * Dr. Eric J. Woodbury, Manager
Tactical Laser Systems Laboratory
Hughes Aircraft Company
Culver City, CA 90203
213/391-0711

* Members of the Industrial Advisory Committee for the LEOT Development Project

EDUCATION PROGRAM REQUIREMENTS

If properly carried out, the needs assessment survey effectively dictates the general content of any subsequent educational program. And, if properly prepared, the educational materials may be arranged to accomodate any such program. (Modularized materials provide maximum flexibility in arrangement.) But the requirements of a program go far beyond content and materials.

Most post-secondary schools offering technician preparation receive state support and operate under state regulations. In most states, approvals for new course offerings require certain formalities. These requirements vary but little from state to state, and the dissemination activity should include a service capability for assisting the schools over this hurdle. In most instances the input consists of a curriculum outline and a brief justification for the course in terms of needs of employers and students served. The latter should be easily abstracted from the needs assessment.

Based on local or regional needs, any school interested in adapting a curriculum to its program should be able to look to the disseminator for considerable assistance in planning. A well planned, comprehensive program planning guide provides a major portion of such support, as does a definitive course outline. But the schools should be afforded additional help, such as counseling based on experience gained from the assessment survey and from previous programs. Usually the most reassuring measure a disseminator can offer a school is reference to prior or existing successful programs. A knowledge of what has worked (or has not worked) elsewhere may be the greatest curriculum planning tool and educator can possess.

The criteria for selecting a local industrial advisory committee differs substantially from those used in selecting a national committee. In general, the purposes of a local industrial advisory committee are twofold:

- To provide expert counsel in determining local needs and selecting course content.
- To provide short upgrading and updating programs for employers in local industries (a potentially important service that employers usually welcome).
- To provide a direct interrelationship between the educational institution and local employers of graduates of the technology.

This latter purpose provides a channel for affording employment op-

portunities to course graduates. And it allows the school to maintain an ongoing evaluation of course effectiveness, especially with regard to relevancy, currency and validity. The former purpose ensures that these factors will be instilled in the course initially.

Experience from the LEOT project provided overwhelming evidence of the usefulness of having a carefully chosen national industrial advisory committee. Whenever possible, one or more members of the national committee should serve as the nucleus of a local industrial advisory committee. Their presence on the local committee insures a continuity both of purpose and of overview with the materials development dissemination projects. For example, a local committee presently being formed in support of an optional LEOT curriculum in the Electronics Department (NM) Technical-Vocational Institute, includes national committee members, Dr. Arthur Guenther, Mr. D. C. Winburn and Mr. Dan Hull. Also on this local industrial advisory committee are several local representatives from area industries that employ LEO technicians.

In most instances the existence of one or more competent faculty staff members precedes a school's interest in a new or different technical course offering (a successful school program requires a key individual on the faculty as well as a firm commitment from the school's top administrator or executive). In such instances some teacher training or upgrading may be needed, and the disseminator should be prepared to fulfill this requirement.

In other situations the schools may need to secure qualified instructors. From its industrial advisory committee associations and technical societies, the disseminator should be able to suggest possible channels through which the schools might approach such personnel. This area requires considerable discretion and constraint, however, since the diversion of personnel can not be allowed to impair the disseminator's rapport with industry, institutions or its industrial advisory committee.

New technology equipment and facilities acquisition oftentimes can be an anathema for even the most progressive teaching institutions. Thus, all the intricacies of this requirement must be understood by the disseminator, along with the governmental requisition, and an acute awareness of alternate ways of making equipment (and facilities, in some instances) available, such as loans and gifts of equipment from manufacturers and distributors. The pilot LEOT program carried out by Texas State Technical Institute (Waco, TX) netted laser equipment donations from industry in excess of \$200,000.00. Much of this equipment came from companies represented on the industrial advisory committee and from employers of TSTI's LEOT program graduates. And, while this situation may not be typical of what every school adopting a new-technology teaching program can expect, it does indicate the reality of support that can be extracted from an involved industry.

The dissemination literature should include a comprehensive

list of applicable equipment, prices and potential sources, and typical laboratory layouts in sufficient detail to facilitate planning. Also, the disseminator should be available for consultation and, whenever appropriate, help make arrangements for school planners to visit existing facilities and ongoing programs.

Long before the preceding requirements are considered, a school must forecast student interest in the program. If the needs assessment survey achieves its goal, student response to a course or curriculum offering should be reasonably predictable. Therefore, the disseminator should make available, through publications and counseling, such data as will be useful to the school in determining potential enrollment and curriculum requirements.

For the LEOT training, TERC-SW found that news releases, descriptive pamphlets and the routine school procedures for publicizing a course attracted an adequate response. Other methods considered, though not used in developing the model, were deemed to have potential application for other course offerings. These include:

- Flyers and/or handouts for state employment agencies handling CETA applicants and others.
- Media advertising.
- Direct and/or indirect contact with high-school counselors.

In captive situations, such as employer-sponsored retraining programs, no such recruiting procedures are required.

In in-house, company-sponsored technician retraining or technical upgrading, only three of the requirements discussed are of concern to the disseminator:

- Curriculum planning.
- Faculty selection.
- Equipment and facilities acquisition.

Primarily, curriculum planning for technicians already employed in the industry consists of the following:

- Determining existing level of competence.
- Determining desired level of competence.
- Selecting those curriculum materials (modules) that provide the information needed to upgrade the existing level of competence to the desired level.

Therefore, planning assistance provided by the disseminator - derived from familiarity with the curriculum materials - must comply with the technicians' and the industry's immediate and real needs.

In most instances a faculty staff for an industry-sponsored course offering will come out of the industry. In these instances, some teacher training may be required. If so, it should be provided by the disseminator along with the selected curriculum materials. Such training usually consists of a brief but intensive review of the new material.

When an instructor from outside the industry is required or preferred, the disseminator should be prepared to offer a list of qualified, available individuals. From that list, the industry sponsor may select a faculty and negotiate its own arrangement.

For industry, the disseminator's responsibility in dealing with this requirement goes little beyond providing a listing of needed equipment and suggested classroom layouts. Experience has shown that employer-sponsored retraining programs usually de-emphasize or eliminate most of the labs since the employees are usually already in contact with the equipment. In most instances the sponsor will be able to provide or arrange for access to equipment and facilities with minimum guidance from a third party.

Curricula for technical education can assume any of five different traditional formats.

- Seminars.
- Short courses.
- Extension (continuing education) courses.
- Formal (classroom) courses.
- Correspondence courses.

A formal assembly of students (or graduate technicians) studying under an instructor but exchanging experiences, experiment results and technical know-how through reports and discussions, constitutes a seminar. Such assemblies may be of lesser duration but often span anywhere from a few hours to a few days of intensive instruction.

Several seminars were conducted as an aspect of the LEOT dissemination model development project; typical of this activity are these two:

"Fundamentals of Laser Devices," 9/15/76
Professional Advancement Course given
at the Laser Institute of America's
national meeting in New York City.

"Lasers in Construction," for 40+ instructors attending the 19th Annual Convention of Two-Year Associated Schools of Construction. Philadelphia, Pa.

Selected modular material developed in the LEOT project fitted readily into the seminar format.

As an upgrade or retrain tool, adaptations of the flexible LEOT materials enjoy widespread use. Exemplary of these short courses are the following:

"Introduction and Application of Lasers," sponsored by the Laser Institute of America (LIA), the University of Cincinnati and TERC-SW, 7/28/75 through 8/1/75. Course 1 of the LEOT materials provided the course contents and study materials.

"Laser Radiometry and Beam Diagnostics," sponsored by the LIA (Palo Alto, California) 5/17/76 through 5/21/76. Note: LIA sponsored at least ten short courses as well as six or more seminars during 1976, all using the LEOT materials with notable success.

Short courses, in general, have been specially designed to present subjects of specific interest to the attendees from industry, schools and other organizations. To date, almost all short courses have been for the purpose of introducing new technology or of upgrading or retraining technicians and teachers. Without exception, the short courses have utilized successfully the modular curriculum materials on a selective basis.

Success of the short courses in upgrading technician comprehension only pointed to a greater need for including significant laser/electro-optics content in existing technician training curricula. Several such programs were developed; for example:

- A LEOT curriculum was incorporated into an existing Electronics Technology program at Vincennes University (Indiana) in the fall of 1975.
- An AS degree program for LEO technician has been in existence at TSTI since 1974.

- A LEOT materials-supported curriculum was created at the University of Houston (Clear Lake City campus) for use in a four-year BS degree program.

Though this list is far from exhaustive (see Appendix G, "LEOT Modules/Ways and Means"), it does provide a suggestion of flexibility of the LEOT materials and the expanse of opportunities for dissemination defined and explored within the scope of the project.

Though the materials appear to offer good potential for correspondence course applications - their self-paced, self-contained modules meet the nominal requirements - formal efforts to disseminate modules in this mode have been deferred for want of time. The major deterrent to this use of the materials appears to be equipment access or simulation - an economic as well as a physical problem, but not an insurmountable one.

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SECTION IV

DISSEMINATION MODEL

As demonstrated, dissemination concepts were put to the test in this model-testing project. Some were poorly conceived, producing results ranging from adequate to excellent in most instances, but disappointing in a few cases. By keeping in mind that certain aspects of the LEOT materials dissemination requirements were atypical, though others were at least indicative, and most were typical, the dissemination model was modified (as shown in Figure 3).

ESSENTIAL ELEMENTS OF MODEL

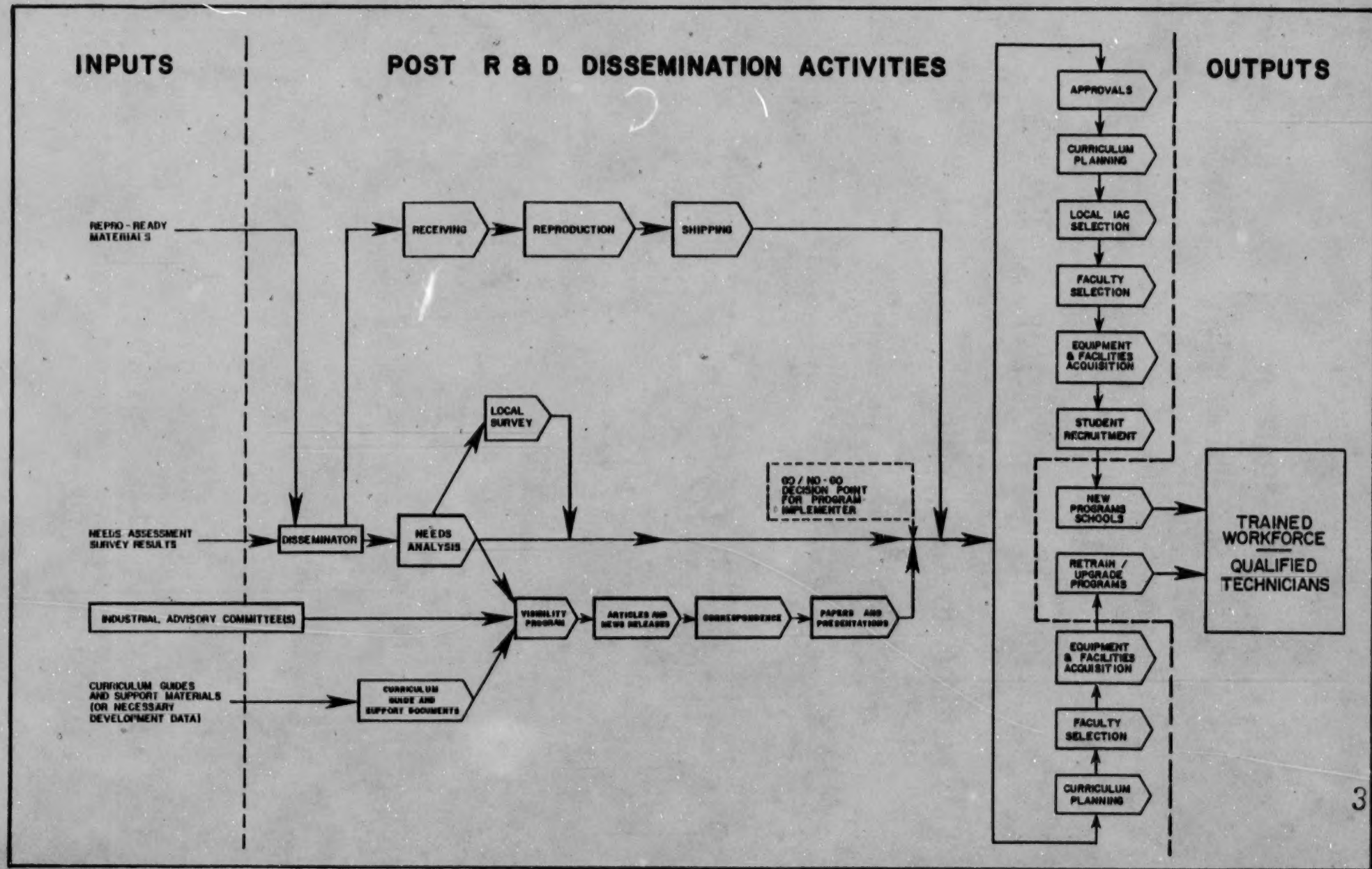
If the educational materials to be disseminated meet the requirements laid out in Section III (flexible, relevant, educationally effective and accompanied by curriculum support documents), the modified model should provide a workable means of placing the materials before an adequate number of students. But certain elements of the model are essential to the achievement of this end.

The disseminator (or third-party disseminating organization) must meet certain minimum qualifying requirements, as detailed in Section III, and listed below:

- Be genuinely interested in national dissemination of the materials.
- Be competent to plan and carry out an aggressive "visibility" campaign.
- Be capable of conducting local needs analyses (and, if necessary, perform the prerequisite needs-assessment survey).
- Be sufficiently oriented to determine educational program requirements for schools and for employer-sponsors.
- Be able to reproduce, or have reproduced, materials rapidly and economically.
- Be able to plan, conduct, monitor and maintain accurate records of a vigorous distribution activity.

Typically, the successful disseminator will exhibit all the above capabilities as well as an existing or developable rapport

Figure 3. Dissemination model constructed from information and experience derived from the LEOT project.



with appropriate educators, employers, technical societies and professional associations. Such rapport might normally be an anticipated product of any successful association with a well chosen industrial advisory committee.

The role of an industrial advisory committee is defined in Section III. In those instances, however, in which the disseminator and materials developed are not the same, the industrial advisory committee may have to be reorganized or restructured or both. In any event, a viable industrial advisory committee is as essential to dissemination as it is to materials development, playing a vital part in:

- Needs assessment.
- Needs analysis.
- Visibility.
- User identification.
- User program development assistance.
- Student/graduate employment opportunity identification.
- Educator/employer interrelations.

Thus, the ability to develop and work with a consientious industrial advisory committee is one more essential requisite for a successful disseminator.

ESSENTIAL ACTIVITIES IN MODEL

More significant, perhaps, than the disseminating elements are the disseminating activities: dissemination is a dynamic progression of events.

By assuming a successful needs-assessment survey, a needs analysis becomes the primary activity of a dissemination project. The analysis determines workforce requirements (as described in Section III and translates these requirements into training needs.

A local or regional survey, much akin to the national survey, but differing in those matters described in Section III, allows the educator or employer to develop a supportable local training program.

The segments of a visibility program also are described in Section III; however, the dynamic aspect of this 'merchandizing' effort cannot be over-emphasized. It is the most critical activity within any dissemination project.

A successful dissemination program results in heavy, quality, materials reproduction requirements (50,000 modules in approximately four years). Thus an organized, economical reproduction activity is vital to the model.

A significant part of the "visibility" activity is correspondence - receiving requests for sample materials, as well as inquiries and requests for explanatory pamphlets and planning documents, and subsequent responses to these requests. But, once dissemination becomes a reality, reproduced materials also begin to flow into the system in large quantities, and reproduced materials must be shipped in a business-like manner.

Knowledge of user requirements, and both a willingness and a capability to provide schools and employers with a full spectrum of assistance in setting up their educational programs, is an essential activity in any successful dissemination.

POST DISSEMINATION EXPECTATIONS

Just as well planned and carefully developed curriculum materials are prerequisite to a successful dissemination program, auspicious results are its insured product. Good materials, well disseminated, provide the basis of an adequately trained workforce. The LEOT materials-development/dissemination program certainly has abetted the training of more proficient technicians and, perhaps more important, it has helped provide a workforce that, in turn, allowed both the technology and the industry to expand more rapidly in the last one-third decade than in the previous full decade.

TIME ELEMENTS OF DISSEMINATION

It has been postulated that a thorough materials development and evaluation project cannot be conducted in less than three years. Add to that a three-year model dissemination project and allow time to evaluate the program graduates' influence upon the technology and industry and nearly a decade may have elapsed since the program was first conceived. This schedule, in most instances, is expanded by time lapses between the major phases (Figure 4). If, however, educational programs could be developed in overlapping, unified projects, this time factor could be reduced substantially (Figure 5). In all cases, and especially those involving urgency (such as energy conservation technician training), this condensed approach should be considered along with any plan to develop educational materials.

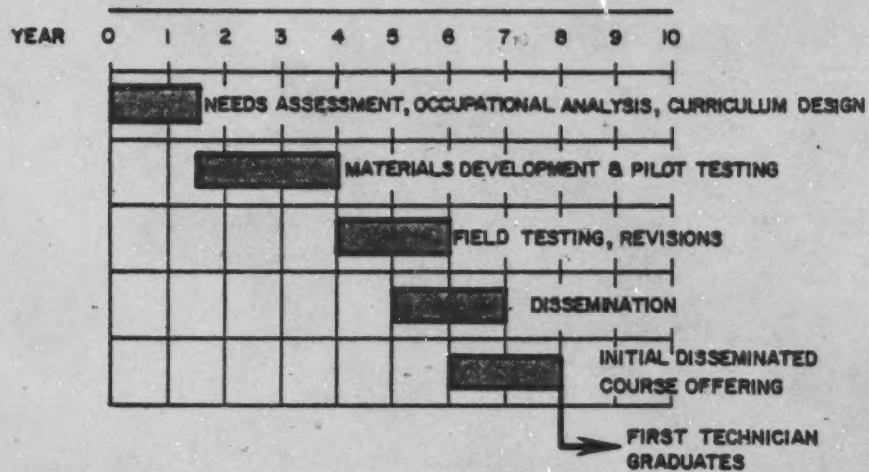


Figure 4. Typical new-technology educational materials development-dissemination-evaluation schedule.

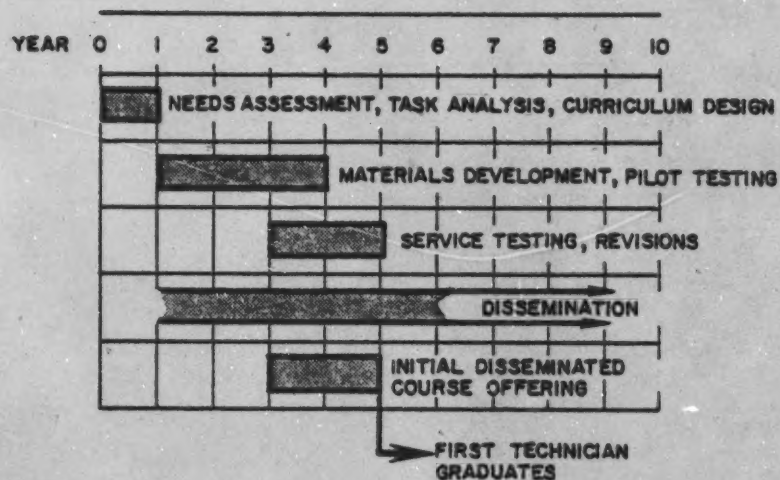


Figure 5. Condensed new-technology educational materials development-dissemination-evaluation schedule.

TIME RELEVANCE OF DISSEMINATION

It is important to recognize that dissemination does not have distinct beginnings and endings. The LEOT materials dissemination, which began at some undesignated and indefinable time during the materials development program, continued through the dissemination project and persists, with no termination in view. The following listing illustrates this interminable feature of dissemination:

At the conclusion of the LEOT development program, the following schools had initiated two-year instructional programs to prepare LEO technicians:

1. Texas State Technical Institute, Waco, TX
(pilot program)
2. San Jose City College, CA
3. Idaho State University, Pocatello
4. Texas State Technical Institute,
Harlingen (bilingual).

During the two-year span of the dissemination project, the following additional schools began LEOT programs:

5. North Central Technical Institute,
Wausau, WI
6. Pasadena City College, CA
7. Vincennes University, IN
8. University of Houston at Clear Lake, TX

Since the dissemination project formally concluded, five additional schools have initiated LEOT programs (and others continue in the planning stage):

9. Albuquerque Technical-Vocational Institute, NM
10. Camden County College, Blackwood, NJ
11. Cincinnati Technical College, OH
12. Lewis M. Lively Area Vocational-Technical
School, Tallahassee, FL
13. New Mexico Highlands University, Las Vegas, NM

DISSEMINATION COST GUIDELINES

The scheduling described above should impose a cost-savings influence upon an overall educational materials development-dissemination-evaluation program. For the dissemination phase only, the LEOT project cost is segmented in Figure 6. These figures may be somewhat unrealistic since not all aspects of the LEOT dissemination project were conducted under the fiscal umbrella of the model-development grant. Also, certain development costs may not have to be repeated in subsequent dissemination activities. The schedule should be used (along with the approximations given in Tables 4 and 5), as a guide and reference.

TABLE 4

DISSEMINATION ACTIVITIES AND COSTS DURING RESEARCH/DEVELOPMENT PERIOD (4 Years)

- 1) Involvement of key employers throughout the country in industrial advisory committee capacity.
- 2) Articles in professional and trade journals (technical and educational), describing project and progress.
- 3) Development of strong, cooperative pilot program(s).
- 4) Responses to inquiries about project (preparation of descriptive materials).

The following costs of dissemination activities average:

10% time of a project staff member.

15% time of secretary/clerk.

3 trips/year to professional society meetings and schools.

\$30.00/month telephone and postage.

\$30.00/month sample materials furnished.

ACTIVITY	MONTH																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
VISIBILITY																								
Professional	.8	.8	.8	.8	.5	.4	.3	.3	.1	.1	.2	.2	.1	.1	.2	.2	.1	.1	.2	.1	.1	.1	.1	.0
Clerical	.5	.5	.3	.3	.2	.2	.1	.1	.0	.0	.1	.0	.0	.1	.0	.0	.1	.0	.0	.1	.0	.0	.1	.0
CATALYST																								
Professional	.3	.3	.3	.3	.7	.7	1.0	1.0	1.0	1.0	.8	.8	.5	.5	.3	.3	.1	.1	.0	.0	.0	0	.0	.0
Clerical	.0	.0	.0	.0	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.0	.1	.0	.1	.0	.1	.0	.1	.0	.0
NEW PROGRAM SUPPORT																								
Professional	.0	.0	.0	.0	.0	.0	.2	.2	.3	.4	.6	.6	.9	.9	.9	.9	.9	.9	.7	.7	.7	.7	.7	.7
Clerical	.0	.0	.0	.0	.0	.0	.1	.1	.1	.1	.1	.1	.1	.1	.1	.0	.1	.0	.1	.0	.1	.0	.1	.1
REVISION, PUBLISHING AND DISTRIBUTING																								
Professional	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Clerical	.5	.5	.7	.7	.7	.7	.7	.7	.8	.8	.7	.8	.8	.7	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9
MONTHLY TOTALS																								
Professional	1.3	1.3	1.3	1.3	1.4	1.3	1.7	1.7	1.6	1.7	1.8	1.8	1.7	1.7	1.6	1.6	1.3	1.3	1.1	1.0	1.0	1.0	1.0	.9
Clerical	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CUMULATIVE TOTALS																								
Professional	1.3	2.6	3.9	5.2	6.6	7.9	9.0	11.2	12.8	14.5	16.3	18.1	19.8	21.5	23.1	24.7	26.0	27.3	28.4	29.4	30.4	31.4	32.4	33.3
Clerical	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0

Figure 6. Time-allocation table for 24-month LEOT Dissemination Project (numbers are person-equivalent levels of effort).

TABLE 5
ESTIMATING TIME AND COST OF DISSEMINATION
(ON NATIONAL BASIS) FOR A NEW TECHNICAL PROGRAM

- 1) Assume: Contributed efforts from 15-20 members of a National Advisory Committee.
 Time and travel to attend two meetings/year.
 Time and travel for four visits to local schools/year.
- 2) Assume: Minimum of two years to initiate instructional programs in 12 strategic sites throughout the country (after curriculum development is completed).
- 3) Assume: Instructional materials (developed) that are modular, relevant and tested.

COST ESTIMATE: POST-DEVELOPMENT PERIOD

Personnel - 24 months

Project Director - full time.

Project Specialist - 0.4 time.

Secretary/typist/clerk/materials supplier - full time.

Travel - 6 national, professional meetings (technical and educational).

Two trips to each of 12 schools - program support.

Advisory committee - 4 meetings - 3 faculty members at each.

12 state or regional meetings - two staff members/meeting.

6 employer site - retraining programs.

Printing - Sample modules (3000)

Brochures (3000)

Curriculum Guides (800)

Surveys (4000 copies - 2 pages - 1 followup).

Postage and Phone to Conduct Surveys: 12 surveys (300 employers each survey - two followup letters).

Estimated cost of such a dissemination project
 = \$150,000.00 (1977 figures).

GENERAL APPLICABILITY OF MODEL

As illustrated, the dissemination model developed in this project should be generally applicable to most educational materials dissemination projects in which the materials input meet those criteria established in Section III.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

As stated in the Introduction, the purpose of this project was to test and revise a proposed model for disseminating new-technology educational materials. Such a model was tested in actual use (on the LEOT materials) and revised.

CONCLUSIONS

The original model dealt only with those post-development activities required to provide visibility to the program materials, to assist organizations and institutions in determining whether they should offer an educational/training program and, if an organization decided to initiate a program, to guide it through the steps of implementation and evaluation.

Except for the duration of the project, the revised model is not significantly different from the proposed model insofar as these post-development activities are concerned; however, it is now evident that program dissemination encompasses a much broader definition than that originally envisioned. Thus, the revised model includes:

- Activities (or tasks) during the research and development phases.
- Criteria by which instructional materials and program-support documents may be evaluated for "suitability for dissemination."
- A strong, national committee of employers who can advise as to where and to what extent programs are generally needed, and assist (on a local basis) in encouraging and guiding selected institutions and organizations in program implementation.
- Post-development activities.

Overall, and in most details, the project enjoyed a high level of success. Certainly, the resultant model meets the project requirements of being "realizable" - dissemination of more than 50,000 curriculum modules substantiates this conclusion consequently, a reasonable conclusion may be drawn that the model can be successfully applied to the dissemination of any properly developed educational materials for a limited or new technology.

A principal, though not overly serious, understated area of the project is compensated for in the revised model: Initially, visibility to educators was under emphasized.

In retrospect, there is some speculation that adequate data collecting mechanisms were not employed in the project, mostly because it was carried out without precedence and in a dicotomized fashion (partially as a part of the materials development project and partially within the framework of the dissemination model project).

Also, it was concluded that careful wording of correspondence could have greatly enhanced the responsiveness of educators, employers and administrators throughout the visibility phase of the dissemination project. Appendix F provides a letter actually used in the project and then exemplifies possible ways this letter could have been improved.

At various times throughout the project, and in writing this report, it was necessary for the staff to pause and recall what was being disseminated. The ultimate objective of the activities was to implement new training and retraining programs in various educational environments throughout the country. However, the immediate objective was not disseminating of a curriculum or a specific training program; rather, it was to give visibility to (and encouraging the use of) relevant, modular instructional materials.

This point may seem insignificant at first. But its importance emerges from the realization that specific curricula and program content was determined on a local needs basis by selecting and arranging the instructional modules into a tailored program. Only in this manner - wherever the materials may be used - are the relevant learning objectives in each module (and the quality of the educational materials in general) instilled with quality and structural diversity essential to a successful instructional program.

RECOMMENDATIONS

Three specific major recommendations appropriately proceed from this successful project and the conclusions stated above.

Recommendation No. 1: At least one additional educational materials development project should be continued through the dissemination phase, using the model presented in this report and invoking a carefully delineated data matrix. (The development project should provide materials ascribing to the suitability requirements outlined in Section III.) Further, the development project should

be supported by a properly structured industrial advisory committee, and it should encompass local needs assessment surveys. An example of an appropriate materials development project is OE Contract No. 300760356, "Development of a Nuclear Reactor Operator Technician (trainee) Curriculum" - this project could effectively dovetail, with no loss of time, into a dissemination project.

Recommendation No. 2: A review of OE-sponsored/developed educational materials from recent years should be undertaken to determine suitability for possible dissemination in accordance with the model. Many technologies of limited or unrealized potential may employ existing curriculum materials and only want for dissemination. If such materials exist in files or elsewhere, they should be surfaced, adapted or updated as needed, and dissemination in accordance with the model.

Recommendation No. 3: A "data bank" system should be developed for each set of instructional modules, which would include management and retrieval of information about the content of each module, thus allowing a local institution to input required job-entry specifications and readout curricula design information (which modules should be taught in what order and with what supporting courses and/or modules).

The first recommendation offers an opportunity to further evaluate the model while carrying out a practical program of dissemination in a significant technology. The second provides a potential for giving pragmatic significance to heretofore poorly disseminated materials and ineffectual development investments. And the third removes curriculum design from the diverse knowledge and memories of individuals into a systemized retrieval mechanism.

Thus, implementation of these recommended applications appear to offer practical opportunities for enhancing the usefulness of educational materials development projects, past and present.

APPENDIX A
Laser-Electro / Optics Curriculum Guide

APPENDIX A
LASER ELECTRO-OPTICS CURRICULUM GUIDE

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I. THE PROGRAM

The emerging technologies of lasers and electro-optics require that new programs be established to train men and women to meet the rapidly growing demands for skilled technicians.

Although optical devices have been partially understood and used for several centuries, it was only a few decades ago that electronic and optical devices were combined into a myriad of new types of electro-optical equipment. With the discovery and development of the first laser in 1960, an entirely new scientific field began to evolve. The laser and electro-optic technologies have reached the state of development where many practical applications currently exist and others are being introduced daily. In 1973 the estimated sales of laser and electro-optical equipment and contracts in this country exceeded 220 million dollars, and the total employment of those engaged in laser activities was 16,600. Surveys indicate that these figures will more than double in the next five years.

The rapid growth of these industries within the past five years has created a shortage of manpower trained in these specialized technologies. Complementary to this need is the attractiveness of this futuristic field to technology students. A pilot program to train technicians in lasers and electro-optics was established at TSTI (Waco) in 1971. Students graduating from this two-year post secondary program have received several unsolicited job offers each, at excellent starting salaries, and have been accepted as entry-level technicians by their employers. Also, a number of two-year graduates have transferred their credits to four year schools.

The purpose of the laser and electro-optics technology program has been to develop a flexible curriculum, to prepare and test instructional materials and to assure that the teaching staff provides students with requisite knowledge and skills. Course outlines, instructional modules, equipment lists, laboratory designs and faculty and administrative support materials have been developed. With good skills in oral and written communications and with relevant training in their specialties, laser and electro-optics technicians become effective members of scientific, engineering and maintenance organizations.

The Field

Although optical devices have been used for several centuries, the field of electro-optics began to develop in the early 1950's when electronic and optical devices were

combined into new types of equipment for tracking, communication, photography and entertainment. With the operation of the first laser in 1960 the fields of optics and electro-optics were restructured into exact engineering disciplines which could be applied to solve some of our more perplexing technical problems. Engineers and scientists began to consider the power in a light beam in the same way (and measured in the same units) as electrical power. The measurement units for parameters describing electro-optical components and devices were redefined into engineering terms.

The laser presented the possibility of using a unique light ray in applications that heretofore had no practical solution. Government funding for laser research in the 1960's was disbursed primarily for the purpose of developing certain military and space applications. However the new lasers and electro-optic devices and techniques that were developed have found widespread applications in solving many practical problems of local communities in the fields of medicine, construction, industrial product testing, computers, entertainment, and the fabrication of metals and other materials.

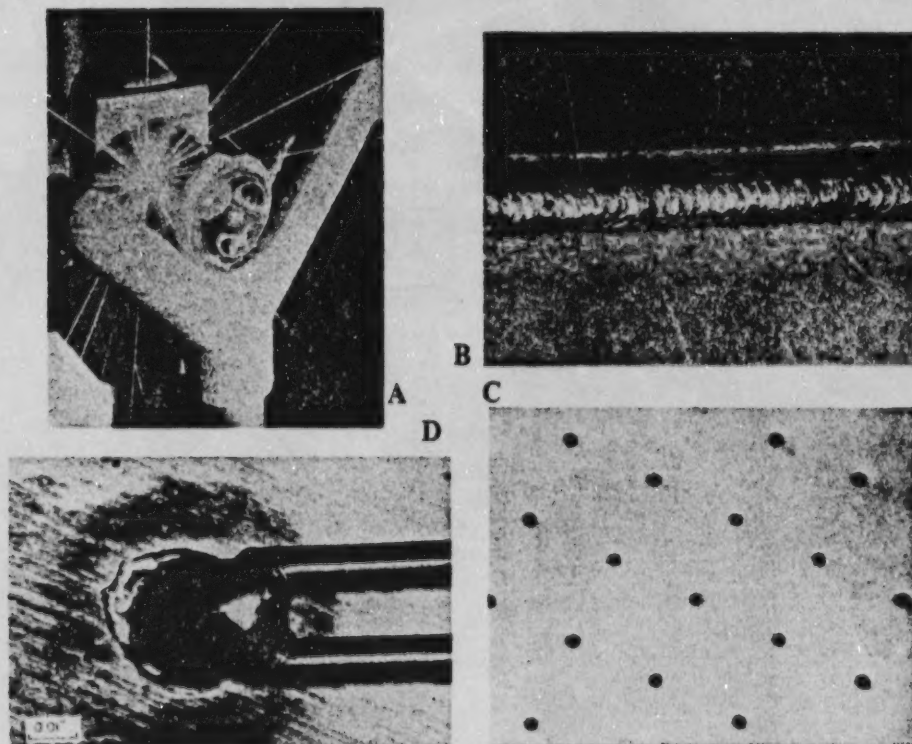


Fig. 1-1. Laser metal working (Honeywell)
 a. Laser vaporization of metal
 b. Laser seam welding c. Laser
 drilling. d. Laser spot welding
 of electronic connections.

Applications

The laser is a device which converts electrical power into a very special beam of optical or light power. The name laser is an acronym for Light Amplification by Stimulated Emission of Radiation, (which is the process actually taking place within the laser). A laser beam is different from ordinary light sources in the following ways:

- o The laser beam is directional and collimated, which means that it spreads very little as it propagates through space. As an illustration, a laser beam transmitted from the earth illuminates an area on the moon less than two miles in diameter. Since the spot is so small the intensity within the beam will remain high.
- o A laser beam is light of a very narrow frequency range - it has the purist color (narrowest bandwidth) of any light source known to man.
- o All emitted light waves from a laser are "in phase" - laser communications systems can process and transmit many simultaneous analog video and digital data signals with no interference problems.
- o The energy in a laser beam can be concentrated into an extremely short duration pulse to produce tremendously high bursts of optical power. This power can cause explosive effects in heating materials to several million degrees. Because of this one of the promising applications of the laser is in the production of nuclear fusion for new electric power production.

Lasers are available in many varieties. They have output wavelengths ranging from the ultraviolet to the visible region and extending to the far infrared. While the output power from some lasers is continuous, other lasers have pulsed outputs with durations in the millisecond (10^{-3}), microsecond (10^{-6}), nanosecond (10^{-9}) and picosecond (10^{-12}) regions. Some lasers are small enough to be held in the hand and have an output power less than a flashlight. Other lasers require a 10,000 square foot building to contain them and are powerful enough to initiate explosives and melt holes through thick metal plates.

Lasers are many things to different people. In welding or drilling, the laser is a heat source. In surgery or clothing manufacturing it is a cutting tool. Designers of radars and communication systems regard lasers as transmitters, producing an electromagnetic carrier of information. The construction industry uses the laser for alignment and distance measurement. A photographer uses the laser to produce a

"hologram", a negative of an interference pattern from which a three-dimensional picture can be reconstructed. Generally a laser is a component of a larger system which uses the laser beam in specific applications to accomplish an objective which had not previously been possible or could not have been done as well.



Fig. 1-2. Laser surgery (University of Cincinnati)

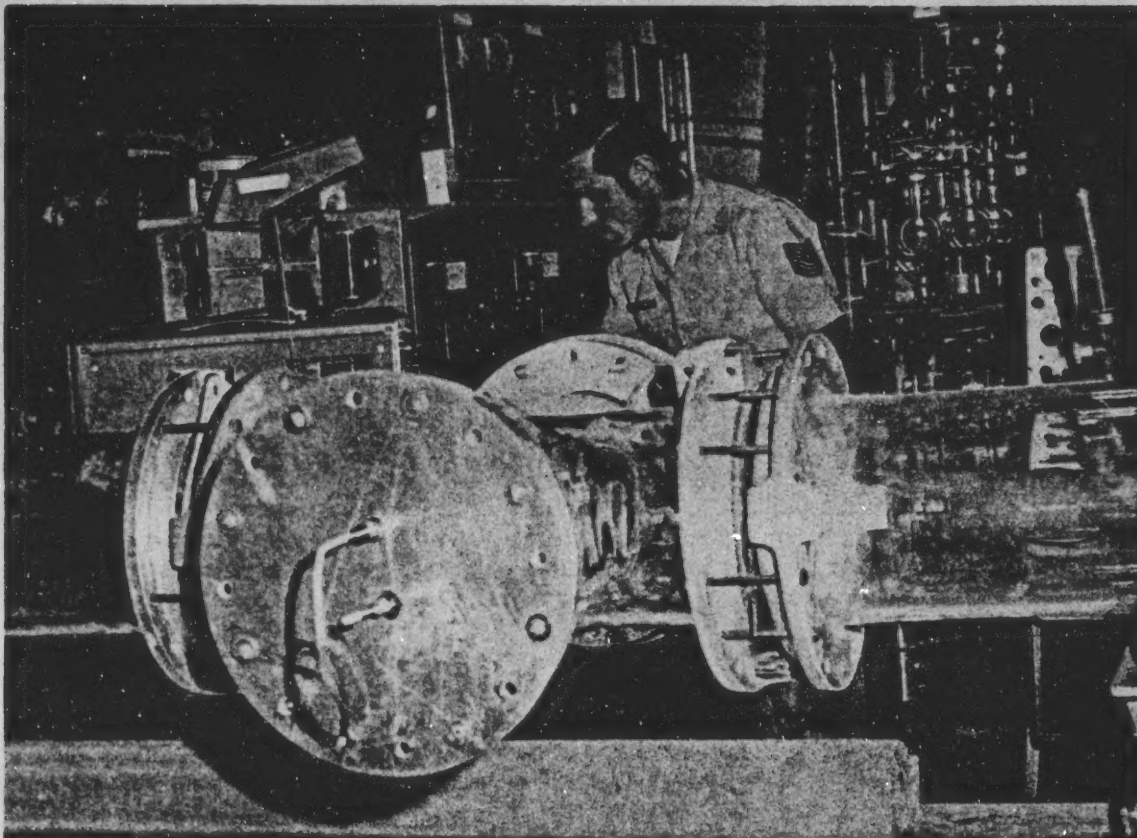


Fig. 1-3. High power laser research at the Air Force Weapons Laboratory. (Albuquerque, New Mexico)

Laser applications which have been identified to date can be grouped into ten specific areas:

1. Construction and Excavation: The laser is used for road, highway and airport runway grading and terracing; in terrain-control and leveling ; office, factory and power plant assembly and leveling; water and sewage pipe installation and alignment; and tunnel excavation.
2. Machining and Materials Working: The laser is used for welding, precision drilling, cutting and grinding of metals; fabric cutting in garment manufacturing; trimming and precision slicing of mechanical and electronic components and circuits.
3. Wideband and Protected Communications Systems: The high frequency coherence of the laser permits the simultaneous transmission of a variety of analog and digital signals.
4. Distance and Angle Measurement: The laser is used in surveying for measuring angles to a fraction of a second and distances to a fraction of a centimeter.

5. Testing and Measurement: Laser holography is used for the non-destructive testing of parts, from large machinery to tires and tiny crystals. Lasers are also used for the testing and monitoring of air and water pollution, and for the dynamic balancing of rotating devices.
6. Data Processing: Lasers are used for the storage and readout of information, from the illumination of complex large-screen displays to the light-emitting device (LED) as in a hand-held calculator.
7. Photo-Optical: Lasers are used as illuminators for high speed photography and in mapping. Electro-optical devices and techniques are used in the study of the Earth's resources by infrared from manned and unmanned satellites, for optical scanners most commonly used for character recognition, in advanced telescopes and microscopes and for specialized lighting applications.
8. Medical: Laser medical applications include surgical operations on the various delicate organs of the body, cancer operations and burn treatment, retinal repair and photocoagulators in ophthalmology, tatoo and skin blemish removal in dermatology, and for diagnostic purposes and the study of single cells.
9. Military and Space Projects: Lasers are frequently used for target acquisition, tracking, ranging, identification, and communication, for range-finding and fire control; and in infrared systems, reconnaissance and tracking.
10. Research and Development: Lasers are being studied as a source for inducing controlled nuclear fusion in the exploration of new means of inexpensive electrical-power generation. They are also presently being used for precise analytical instrumentation; for the study of plasma, its makeup and effects; and for Raman spectroscopy.

Manpower Needs

Every since the concept of a laser was first postulated, the scientific community has possessed an abundance of theoretical expertise to predict new laser materials, techniques, and applications. But since the early 1960's there has been a shortage of trained manpower to test these theoretical ideas. For over a decade, industry has had increasing need for laboratory and field technicians that can implement experimental setups, understand safety precautions as they relate to eye and skin hazards, procure and maintain components, and operate and troubleshoot laser and electro-optical systems. During

this period, industry has had to select electronic engineers and technicians and provide "on the job training" to develop laser and electro-optical technicians. For the most part, this approach has met with only limited success - these "converted techs" usually do not have the fundamentals in lasers and optics and they require years to become familiar with the wide variety of materials, components and special techniques used in the field. This problem is compounded by the lack of training materials in lasers and electro-optics that are of a practical nature rather than theoretical treatise.



Fig. 1-4. Technician operating micromachining laser to trim resistors on integrated circuits.
(KORAD/HADRON)

Until the beginning of this decade the manpower requirements in the field of electro-optics and lasers have been too small to support vocational/technical programs dedicated to training students in this area. However, in recent years the numerous applications of lasers have caused a widespread use and demand for trained personnel in this technology. Today one of the greatest needs in the field is the shortage of trained technicians.

Because the laser is relatively new, because its output can usually be seen, and its applications and effects on materials are unusual, the laser has a futuristic glamour that attracts men and women as students to the field. In less than three years, the Laser/Electro-Optics Technology (LEOT) Department at Texas State Technical Institute has grown from four to over one hundred students. Graduating students have received several unsolicited job offers each from laser, electro optics and electronics companies. Starting salaries have been excellent, exceeding the mean-average salaries of technicians who have achieved skills in almost all of the other engineering specialities and frequently approach the salaries of graduates of four-year institutions - such is the extent of the shortage.

As is the case for workers in other technical fields, optical, electro-optical and laser technicians are employed for design, support, development assistance, sales and field service. In the manufacture of laser and electro-optical systems and components, technicians are needed for assembly, fabrication, and testing.

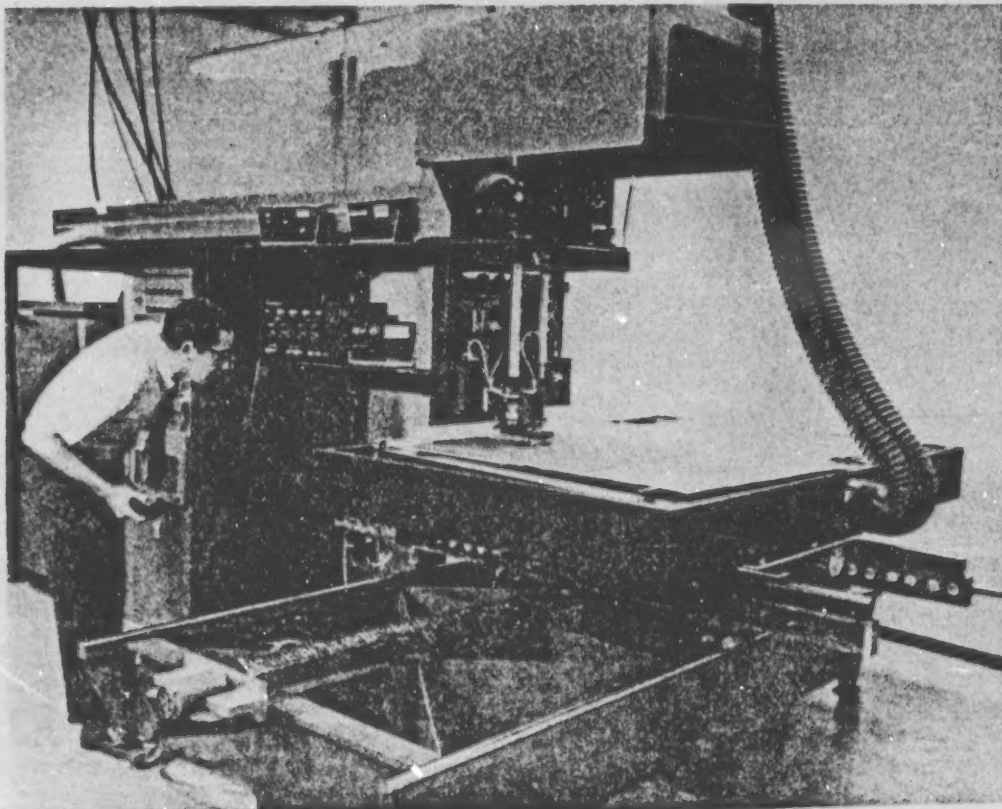


Fig. 1-5. Technician operating laser die-maker to produce steel rule dies for the paper carton industry. (Coherent Radiation)

Before initiating a training program in the field of lasers and/or electro-optics an educational institution should conduct an extensive investigation to assess the need for LEO technicians in the local region or state. The data which should justify or repudiate the feasibility of such a program can be obtained with a survey questionnaire such as the model shown in Appendix D. The implementation of such a survey should be supported by assistance from an Industrial Advisory Committee (see page 4-1) and should include questions pertaining to the need for optics, electro-optics and/or laser technicians.

Skills Required

In order to develop a model curriculum and supportive instructional materials it was necessary to obtain skills profiles for the various functions LEO technicians will be required to perform. In the list that follows, fifteen duties are listed which have been identified from nationwide surveys of employers of optical, electro-optical and laser technicians:

1. Troubleshoots and repairs laser systems.
2. Performs tests and measurements using electronic devices.
3. Performs alignment procedures on optical systems, especially those which involve lasers and laser-related optics.
4. Prepares and reads shop drawings and schematics.
5. Maintains a laboratory notebook, performs data reduction, and prepares reports.
6. Operates interferometers, spectrometers, monochromators and spectrophotometers.
7. Operates laser systems, including intra-cavity modulation and Q-switching devices.
8. Utilizes basic laser and electrical safety practices in the laboratory.
9. Performs optical inspections and cleaning of optical components.
10. Operates and calibrates photodetectors, photomultipliers, optical power meters and calorimeters.

11. Processes photographic film and plates.
12. Produces and reconstructs holograms.
13. Selects laser and optical components based on optical, electronic and mechanical properties using manufacturer's catalogues and other trade publications.
14. Troubleshoots and repairs electro-optic devices.
15. Fabricates and assembles components for laser/electro-optic devices and systems.

From this task list and guidance from the Industrial Advisory Committee, 155 specific tasks were derived and learning objectives were developed which formed the basis for the subject matter in the instructional modules. The modular format allows flexibility in using the instructional materials so that courses and programs can be tailored to meet the needs of employers in the local area.

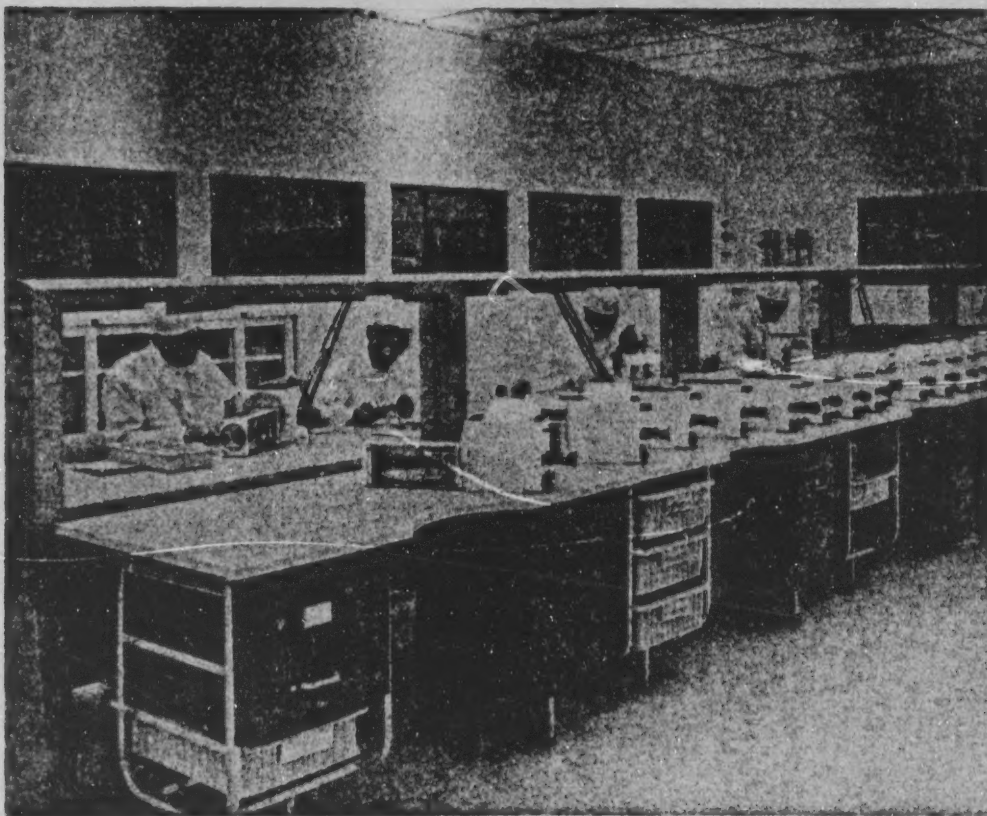


Fig. 1-6. Technicians constructing laser range-finding equipment. (Hughes)

In addition to the fifteen duties listed, the Industrial Advisory Committee stressed very heavily the need for an LEO technician to communicate effectively with engineers, doctors, scientists, production personnel, manufacturers, sales representatives, and purchasing agents. This requires written skills in laboratory notebooks, reports, specifications and letters; verbal skills in presentations, telephone conversations and informal briefings; and a general understanding of the nature and behavior characteristics of highly trained and motivated technical specialists.

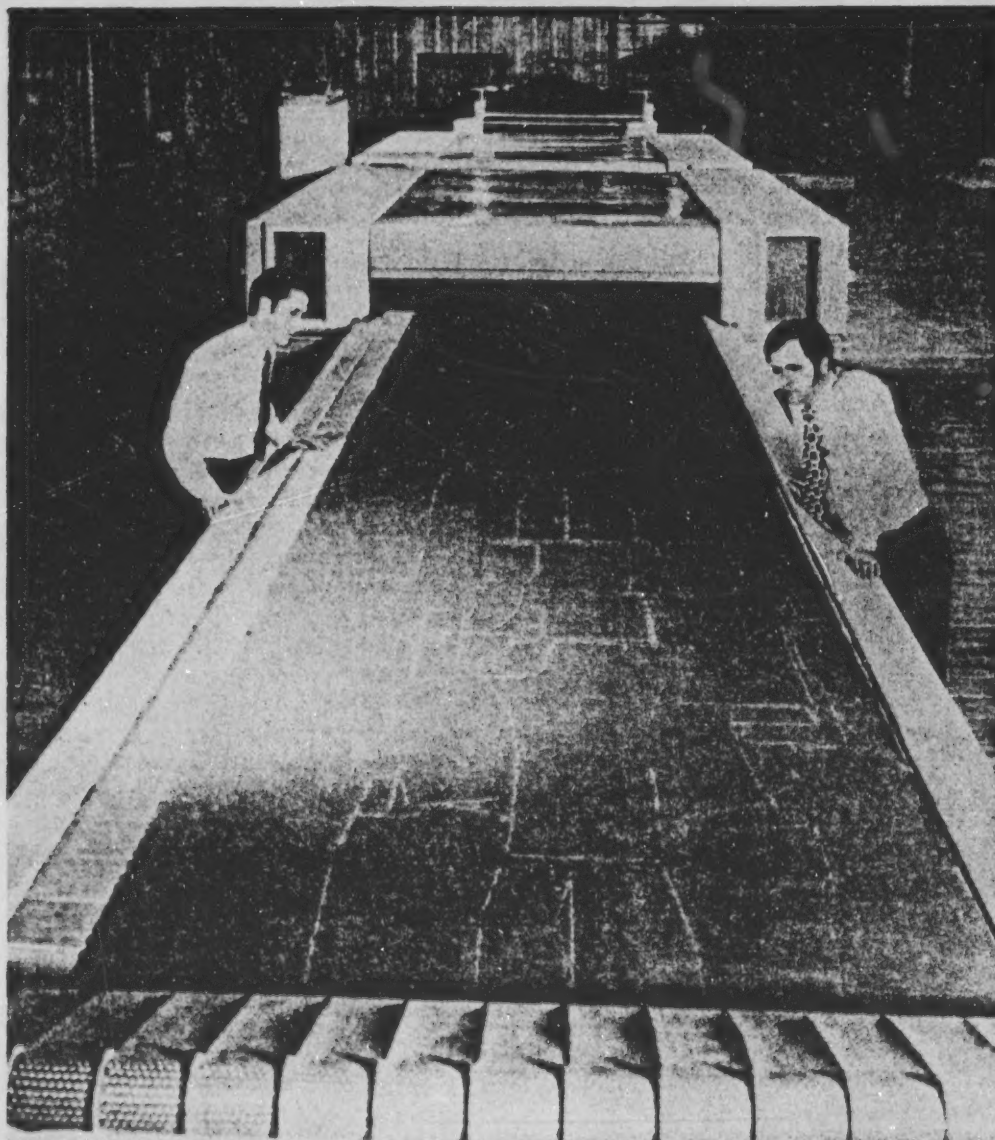


Fig. 1-7. Laser used to cut material for clothing industry. (Hughes)

Program Philosophy

The overall philosophy of the laser and electro-optics technology program can be expressed rather simply:

1. To develop a program that would be flexible in its application to optical, electro-optical and laser technician training.
2. To prepare and test instructional materials in a modular format with measurable objectives, for a two-year post secondary program, operating on a quarter system.
3. To assure that graduating students will be prepared for work and that they will in the future be able to raise their occupational status to the level of their aspirations, through a combination of study in more advanced courses and on-the-job experience.

The skills and knowledge of the present-day laser and electro-optical technician were derived from this emerging technology when work on the LEOT grant was begun. Laser textbooks and materials available at this time are either too theoretical or too simplistic for use in technician training. An advisory committee of educators, scientists and industrialists (see Acknowledgements) assisted the TERC staff in determining the knowledge and skills required for LEOT work. The TERC, LEOT staff then proposed a series of instructional modules (page 2-2) which were further developed with the help of Texas State Technical Institute faculty, and tested by students there. The modules were reviewed for content, format and presentation by the Industrial Advisory Committee and Evaluation Team (see Acknowledgements), many of whose members employ laser and electro-optical technicians. The quality of the resulting instructional materials, and the glamour of lasers themselves, have attracted many capable men and women students and have guaranteed the graduates jobs because their training has been relevant to the world of work.

Each of the more than 100 instructional modules which were developed on the program includes measurable objectives and laboratory oriented learning instructions supportive to these objectives. A modular format for this material was adopted in order to enhance flexibility both in applications and in teaching sequence. Student pre-requisites are intentionally limited to a working knowledge of algebra and trigonometry plus some knowledge of electricity and high-school physics. The use of the "instructional module" has been an important factor in the success of the LEOT program at Texas State Technical Institute.

Depending upon the portion of the program completed by various students, all graduates of the two-year program, at TSTI have been accepted by employers as entry-level technicians. At the end of the first year of the model curriculum, those few who did not desire to continue were immediately placed in jobs as assemblers and fabricators. A number of the two-year graduates transferred their credits to four-year schools with the goal of becoming either designers or managers via electronics, physics, engineering or business-management programs. The acceptance of these LEOT program graduates by both employers and four-year institutions has given the TERC and TSTI program staff an immense feeling of accomplishment.

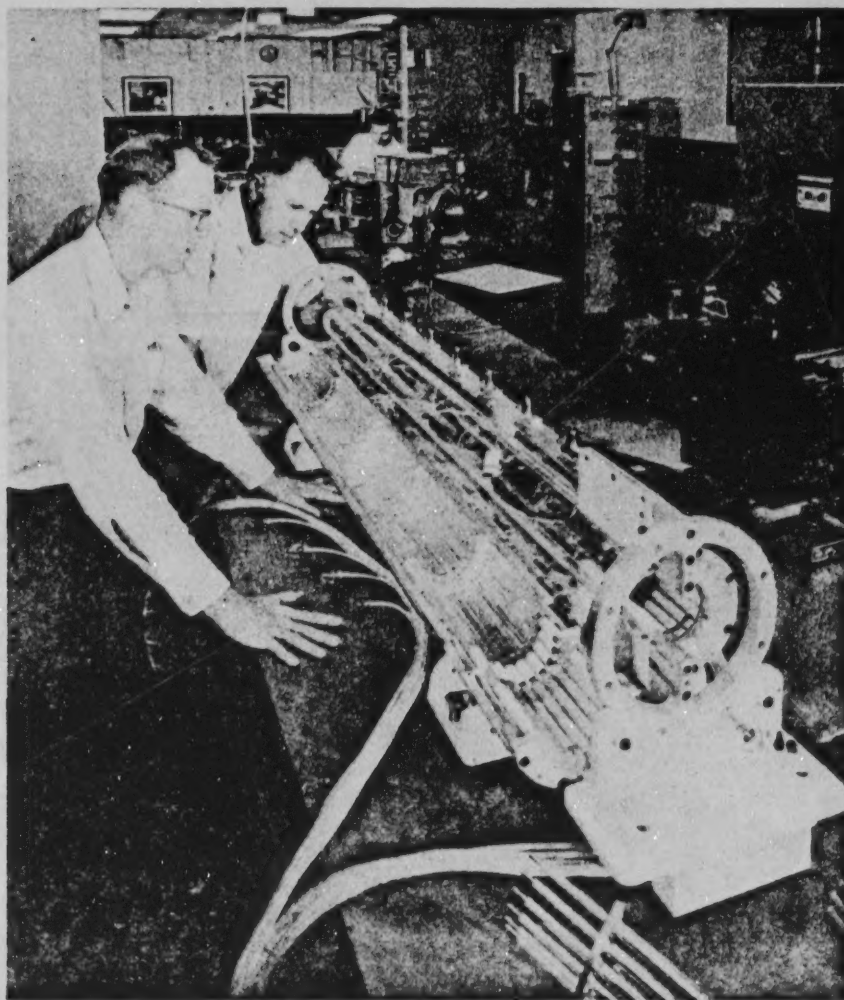


Fig. 1-8. Laser induced fusion research for future production of electric power. (Lawrence Livermore Labs, AEC)

II. THE CURRICULUM

The laser and electro-optical technology (LEOT) instructional materials were developed to support an intensive two-year, full-time curriculum of post-secondary study. The model curriculum and adaptations of it made to fit the facilities and needs of institutions which use it, are designed for maximum flexibility and the greatest possible use of existing classroom and laboratory-oriented courses in physics (optics) electronics, mechanics, drafting, instrumentation, fabrication, communications, English, mathematics, lasers and safety. The program's educational value can be enhanced through summer project options and/or industrial work opportunities.

The materials developed during the course of the TERC LEOT project are adaptable to school semester and quarter systems and are arranged for easy adaptation to local, state and regional accreditation requirements. Individual institutions may wish to implement the full program, or to integrate select groups of modules into existing electronics programs. Also, a number of the 101 supportive instructional modules can be used to enrich existing courses in physics (optics).

Flexibilities

An extensive effort was made to develop as flexible an LEOT program as possible. Supportive instructional modules (page 2-2) and faculty and administrator planning and guidance documents (Appendix E) were devised to assist program faculty in a number of ways. The equipment, materials and facilities described in this report are specified for a class of eight to sixteen students, involved in three lecture and three laboratory learning hours per week. With efficient scheduling of labs or by using "open labs" three sections of a course can be conducted concurrently in a quarter using the same equipment and facilities. Thus, the program can be adapted for the training of as few as eight and as many as forty-eight students per year while still retaining its cost-effectiveness, once initial laboratory equipment purchase requirements have been satisfied.

The course-hour data on the following pages are given as examples of quarter systems. Course outlines and program arrangement for semester or other systems can be obtained from TERC by specific request. The courses and modules have been carefully prepared and arranged for easy adaptation to local, state and regional accreditation requirements. For example, the core for the quarter system, consisting of ten technical courses, is supported by a total of 101 instructional modules. Complementary physics, mathematics, communications-skills

Laser Electro-Optics Technology

Course Outline By

Instructional Module Titles

A-18

COURSE 1. INTRODUCTION TO LASERS

- UNIT I. LASER FUNDAMENTALS
 MODULE 1-1. ELEMENTS AND OPERATION OF A LASER
 MODULE 1-2. OPERATION OF AN OPTICAL POWER METER
 MODULE 1-3. WAVE PROPERTIES OF LIGHT
 MODULE 1-4. INTRODUCTION TO LASER SAFETY
- UNIT II. LASER PHYSICS
 MODULE 1-5. ENERGY LEVELS IN ATOMS
 MODULE 1-6. LASING ACTION
 MODULE 1-7. OPTICAL CAVITIES AND MODES OF OSCILLATION
- UNIT III. PROPERTIES OF LASER LIGHT
 MODULE 1-8. COHERENCE
 MODULE 1-9. POWER AND DIRECTIONALITY
- UNIT IV. LASER SYSTEMS
 MODULE 1-10. HELIUM-NEON GAS LASERS - A CASE STUDY
 MODULE 1-11. LASER CLASSIFICATIONS AND OPERATING MODES

COURSE 2. GEOMETRICAL OPTICS

- UNIT I. INTRODUCTION TO GEOMETRICAL OPTICS
 MODULE 2-1. LIGHT RAYS
 MODULE 2-2. PRINCIPLES OF REFLECTION
 MODULE 2-3. REFLECTION OF LIGHT AT A PLANE BOUNDARY
 MODULE 2-4. REFLECTION OF LIGHT AT A SPHERICAL SURFACE
 MODULE 2-5. PRINCIPLES OF REFRACTION
 MODULE 2-6. REFRACTION OF LIGHT AT A PLANE BOUNDARY
 MODULE 2-7. REFRACTION OF LIGHT AT A CURVED BOUNDARY
- UNIT II. OPTICAL COMPONENTS & SYSTEMS
 MODULE 2-8. IMAGING WITH A SINGLE LENS
 MODULE 2-9. IMAGING WITH A MULTIPLE LENS
 MODULE 2-10. F-STOPS AND APERTURES
 MODULE 2-11. OPTICAL SYSTEMS

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COURSE 3. LASER TECHNOLOGY

- UNIT I. LASER COMPONENTS & MEASUREMENTS
 MODULE 3-1. PULSED LASER FLASHLAMPS & POWER SUPPLIES
 MODULE 3-2. POWER SOURCES & OPTICAL PUMPING FOR CW LASERS
 MODULE 3-3. CW SOLID LASERS - EFFICIENCY AND COOLING
 MODULE 3-4. LASER POWER AND ENERGY MEASUREMENTS
- UNIT II. LASER SYSTEMS
 MODULE 3-5. ION GAS LASERS
 MODULE 3-6. MOLECULAR GAS LASERS
 MODULE 3-7. OPTICALLY PUMPED CW SOLID LASERS
 MODULE 3-8. OPTICALLY PUMPED, PULSED SOLID LASERS
 MODULE 3-9. LASER Q-SWITCHING - GIANT PULSES
 MODULE 3-10. ORGANIC DYE LASERS
 MODULE 3-11. SEMICONDUCTOR LASERS

COURSE 4. EXPERIMENTAL OPTICAL METHODS

- UNIT I. OPTICAL MATERIALS
 MODULE 4-1. TYPES AND PROPERTIES OF OPTICAL MATERIALS
 MODULE 4-2. LIMITATIONS AND TESTING OF OPTICAL MATERIALS
 MODULE 4-3. CLEANING OPTICAL COMPONENTS
- UNIT II. GLASS FABRICATION
 MODULE 4-4. GLASSES AND GLASS WORKING EQUIPMENT
 MODULE 4-5. GLASS FORMING OPERATIONS
 MODULE 4-6. GLASS SEALS
- UNIT III. VACUUM TECHNOLOGY
 MODULE 4-7. VACUUM SYSTEMS
 MODULE 4-8. EVACUATION & CHARGING OF LOW-PRESSURE DEVICES
 MODULE 4-9. VACUUM DEPOSITION OF THIN FILMS

COURSE 5. WAVE OPTICS

- UNIT I. FUNDAMENTALS OF LIGHT
 MODULE 5-1. LIGHT: BASIC CONCEPTS
 MODULE 5-2. LIGHT SOURCES AND MEASUREMENTS
 MODULE 5-3. LIGHT SOURCES: SPECTRAL CONSIDERATIONS
- UNIT II. REFLECTION AND REFRACTION; A WAVE TREATMENT
 MODULE 5-4. REFLECTION OF LIGHT
 MODULE 5-5. REFRACTION OF LIGHT
- UNIT III. ATTENUATION OF LIGHT IN A MEDIUM
 MODULE 5-6. ADSORPTION OF LIGHT
 MODULE 5-7. SCATTERING OF LIGHT
- UNIT IV. INTERFERENCE AND DIFFRACTION OF LIGHT WAVES
 MODULE 5-8. INTERFERENCE OF LIGHT
 MODULE 5-9. DIFFRACTION OF LIGHT
 MODULE 5-10. HOLOGRAPHY
- UNIT V. POLARIZATION EFFECTS
 MODULE 5-11. POLARIZATION OF LIGHT

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COURSE 6. LASER AND ELECTRO-OPTIC COMPONENTS

- UNIT I. SUPPORT HARDWARE FOR OPTICAL COMPONENTS
MODULE 6-1. OPTICAL TABLES AND BENCHES
MODULE 6-2. COMPONENT SUPPORTS
- UNIT II. LASER AND ELECTRO-OPTIC COMPONENTS
MODULE 6-3. PHOTOGRAPHIC COMPONENTS & SUPPLIES
MODULE 6-4. WINDOWS
MODULE 6-5. MIRRORS, PLATS AND ETALONS
MODULE 6-6. FILTERS AND BEAM SPLITTERS
MODULE 6-7. PRISMS
MODULE 6-8. LENSES
MODULE 6-9. GRATINGS
MODULE 6-10. POLARIZERS
MODULE 6-11. NON-LINEAR MATERIALS

COURSE 7. LASER/ELECTRO-OPTIC DEVICES

- UNIT I. OPTICAL DETECTION DEVICES
MODULE 7-1. PHOTO DETECTORS
MODULE 7-2. LASER POWER & ENERGY DETECTORS
- UNIT II. PHOTOGRAPHIC TECHNIQUES
MODULE 7-3. PHOTO INSTRUMENTATION EQUIPMENT
MODULE 7-4. HOLOGRAPHIC TECHNIQUES AND EQUIPMENT
- UNIT III. LASER BEAM MANIPULATORS
MODULE 7-5. COLLIMATORS AND AUTOCOLLIMATORS
MODULE 7-6. BEAM EXPANDERS AND SPATIAL FILTERS
MODULE 7-7. ISOLATORS
- UNIT IV. MODULATION DEVICES AND Q-SWITCHING
MODULE 7-8. MECHANICAL AND BLEACHABLE DYE METHODS
MODULE 7-9. ELECTRO-OPTIC
MODULE 7-10. ACOUSTO-OPTIC

COURSE 8. LASER APPLICATIONS

- UNIT I. MATERIALS PROCESSING
MODULE 8-1. WELDING
MODULE 8-2. DYNAMIC CUTTING AND DRILLING
- UNIT II. DATA PROCESSING
MODULE 8-3. DATA RECORDING & MANIPULATING
MODULE 8-4. DATA DISPLAY
- UNIT III. TESTING AND MONITORING
MODULE 8-5. ENVIRONMENTAL TESTING & MONITORING
MODULE 8-6. NONDESTRUCTIVE TESTING
- UNIT IV. RANGING AND ANGLE TRACKING
MODULE 8-7. RANGE FINDING
MODULE 8-8. ALIGNMENT AND ANGLE TRACKING
- UNIT V. MEDICAL APPLICATIONS
MODULE 8-9. LASERS IN MEDICINE, SURGERY & DENTISTRY
- UNIT VI. COMMUNICATIONS
MODULE 8-10. LASER COMMUNICATION SYSTEMS

COURSE 9. LASER PROJECTS

- UNIT I. LASER/ELECTRO-OPTIC SYSTEMS
MODULE 9-1. OPEN-CAVITY HELIUM-NEON LASER
MODULE 9-2. COMMUNICATIONS LINK
MODULE 9-3. CW PUMPED Nd:YAG LASER
MODULE 9-4. CARBON DIOXIDE LASER
- UNIT II. ELECTRO-OPTIC DEVICES
MODULE 9-5. AUTOCOLLIMATOR
MODULE 9-6. POWER SUPPLY AND CALIBRATION OF A PHOTOMULTIPLIER
MODULE 9-7. OPTICAL POWER METER FOR CW LASERS

COURSE 10. LASER/ELECTRO-OPTIC MEASUREMENTS

- UNIT I. SPECTRAL MEASUREMENTS
MODULE 10-1. SPECTROMETERS
MODULE 10-2. MONOCHROMATORS
MODULE 10-3. SPECTROPHOTOMETERS
- UNIT II. INTERFEROMETRIC MEASUREMENTS
MODULE 10-4. MICHELSON INTERFEROMETER
MODULE 10-5. FABRY-PEROT INTERFEROMETER
MODULE 10-6. TAYMAN-GREEN INTERFEROMETER
MODULE 10-7. MACH-ZEHNDER INTERFEROMETER
- UNIT II. SPATIAL RESOLUTION
MODULE 10-8. SPATIAL RESOLUTION OF OPTICAL SYSTEMS

SUPPLEMENTARY MODULES

1. LABORATORY NOTEBOOK PREPARATION
2. MEASUREMENTS AND ERRORS

**MODEL CURRICULUM FOR
LASER ELECTRO-OPTICS TECHNOLOGY**

COURSE	QUARTER PLAN - Hours Per Week				
	Class	Lab	Study	Total	Credit
<u>First Quarter</u>					
Mathematics I	4	0	8	12	4
DC Circuits	3	3	6	12	4
Physics	3	3	6	12	4
Introduction to Lasers	3	3	6	12	4
	<u>13</u>	<u>9</u>	<u>26</u>	<u>48</u>	<u>16</u>
<u>Second Quarter</u>					
Mathematics II	4	0	8	12	4
Drafting	2	3	4	9	3
AC Circuits	3	3	6	12	4
Electronic and Mechanical Fabrication	1	3	2	6	2
Geometrical Optics	3	3	6	12	4
	<u>13</u>	<u>12</u>	<u>26</u>	<u>51</u>	<u>17</u>
<u>Third Quarter</u>					
Wave Optics	3	3	6	12	4
Laser/Electro-Optics Components	3	3	6	12	4
Electronic Instrumentation and Calibrations	3	3	6	12	4
Semiconductor and Vacuum Tube Fundamentals	3	3	6	12	4
	<u>12</u>	<u>12</u>	<u>24</u>	<u>48</u>	<u>16</u>
<u>Fourth Quarter</u>					
Laser Technology	3	3	6	12	4
Experimental Optical Methods	3	3	6	12	4
Technical Communications	3	0	6	9	3
Industrial Safety	2	0	4	6	2
Solid State Circuit Analysis	3	3	6	12	4
	<u>14</u>	<u>9</u>	<u>28</u>	<u>51</u>	<u>17</u>
<u>Fifth Quarter</u>					
Laser Electro-Optic Devices	3	3	6	12	4
Laser Electro-Optic Measurement	3	3	6	12	4
Digital Circuits I	3	3	6	12	4
Machine Tool and Shop Practice	3	3	6	12	4
	<u>12</u>	<u>12</u>	<u>24</u>	<u>48</u>	<u>16</u>
<u>Sixth Quarter</u>					
Laser Applications	3	3	6	12	4
Laser Projects	3	3	6	12	4
Digital Circuits II	3	3	6	12	4
Introduction to Computer Hardware	3	3	6	12	4
	<u>12</u>	<u>12</u>	<u>24</u>	<u>48</u>	<u>16</u>

courses and electives round out the illustrative model curriculum.

Model Curriculum Sequence

The curriculum sequence which follows is designed to concentrate on the primary skill requirements for laser and electro-optical technicians. It fully satisfies training requirements for the fifteen LEOT duties previously described. The content of the technical-specialty courses is suggested, but should be left flexible to allow for the course sequencing which best fits a specific institution's needs.

Curriculum sequences are given for quarter systems of instructional modularization. Semester curriculum plans can be supplied upon request.

COURSE DESCRIPTIONS

Course descriptions are provided which match the course titles on the previous pages. Although the topics listed under course title headings are not all-inclusive, their depth of coverage makes them suitable for use in school catalogs. LEOT program planning should be based on a study of the topics listed in each of the supportive instructional modules, and from other material selected by LEOT planners at each particular institution. This procedure will yield the depth of classroom and laboratory planning and sequencing necessary to assure the success of the program.

FIRST QUARTER

Mathematics I

Types of numbers, basic arithmetic operations, powers of 10 and scientific notation, basic algebraic expressions and operations, exponents, powers, roots, basic laws of exponents, concept of the function, linear algebraic functions, quadratic algebraic functions, graphical representation of functions, rectangular coordinate system, equation of a straight line, distance between 2 points, slope of a line, intercepts, simultaneous linear equations, 2×2 and 3×3 determinants, use of slide rule and electronic calculator for multiplication, division, powers, roots.

DC Circuits

Simple model of the atom, charge, electric field, potential difference, current, resistance, Ohm's Law, power law, Kirchhoff's equations (series circuits, parallel circuits, series-parallel circuits), resistor color code, potentiometers, rheostats and voltage dividers, Thevenin's and Norton's equivalent circuit theorems, types and properties of batteries, electrical symbols and schematic diagrams, measuring direct

current and voltage with a VOM, conversion of heat, light and pressure into electricity, the ohmmeter, simple switches, the voltmeter, the ammeter, resistive input transducers (thermistors, platinum resistance thermometer, strain gauge), magnetism, magnetic fields, induction, DC motors.

Physics

International System (SI) of units, dimensional analysis, conversion from one set of units to another, fundamental and derived quantities, measuring instruments, significant figures, vectors and scales, static forces, kinematics, simple harmonic motion, laws of motion, work, energy, power, mechanics of fluids, temperature, thermal expansion, gas laws, kinetic theory of an ideal gas, heat exchange, specific heat, phases of matter, longitudinal and transverse waves, wave fronts, phase, amplitude, wavelength, wave speed, reflection and standing waves, sound waves, interference and beats.

Introduction to Lasers

Elements of a laser, operation of a helium-neon gas laser, laser physics, optical cavities, properties of laser light, survey of laser systems.

SECOND QUARTER

Mathematics II

Review of formulas from plane and solid geometry, radian measure, angular motion three-dimensional coordinate systems (rectangular, cylindrical, spherical), trigonometric functions and identities, small angle approximations, plane polar coordinates, graphs of trig functions, inverse trig functions, exponential functions, logarithms, use of log tables, logarithmic functions, semilog and log-log graphical plots, addition and subtraction of vectors, vector components, unit vectors, vector and scalar products, use of slide rule and electronic calculator for trig functions, logarithms, and exponential functions, experimental error and significant figures (absolute and relative error, addition, subtraction, multiplication and division of experimental numbers), probable error, standard deviation.

Drafting

Basic exercises in lettering, use of drawing instruments, fabrication sketches, geometrical construction, pictorials and dimensioning.

AC Circuits

Electromagnetism, alternating current, a simple a-c motor, sine waves and their properties, capacitance, dielectric strength, types of capacitors, RC circuits, capacitive reactance, impedance, phase angles, vector representation of instantaneous voltages, capacitors in series and in parallel,

time constants, inductance, Lenz's law, Faraday's law, RL circuits, inductive reactance, transformers, RLC series and parallel circuits, AC generators, 3-phase circuits, 3-phase induction motors, 3-phase synchronous motors, capacitive input and inductive input transducers.

Electronic and Mechanical Fabrication

Shop safety, use of handtools, measuring instruments, bench work, use of jigs, assembly of machined parts, use of hand drill and drill press and bender, soldering and desoldering techniques, circuit component layout, circuit board fabrication, cabling, color codes and wire sizes.

Geometrical Optics

Reflection and refraction of light, graphical ray tracing techniques, f-stops and apertures, imaging with a single lens, types of lenses, primary and secondary focal points, thin lens equation, imaging with multiple lenses, simple optical systems (microscopes, telescopes, collimators).

THIRD QUARTER

Wave Optics

Light as an electromagnetic wave, light sources, radiometric units, absorption, scattering, interference, diffraction, holography and polarization.

Laser and Electro-Optic Components

Optical tables and benches, component support, properties and uses of filters, optical windows, beamsplitters, etalons, mirrors, lenses, polarizers, gratings, photographic supplies and non-linear materials.

Electronic Instrumentation and Calibrations

Meter movements, calibration of ohmmeters, voltmeters, ammeters, use of shunts, potentiometer circuits, Wheatstone bridge, AC bridges (Wien, Owens, Hay, capacitance, inductance), use of function generator, VTVM, recording potentiometer (strip chart rec.), use of thermocouples, wattmeters, emphasis on use of the oscilloscope for voltage, phase and frequency measurements and troubleshooting, familiarization with various types of scopes (vectorscopes, dual-trace with triggered sweep, sampling scopes).

Semiconductor and Vacuum Tube Fundamentals

Physical model for semiconductors, the p-n junction and diode action, vacuum diodes, rectification, half-wave and full-wave rectifiers, bridge rectifier, voltage doubler and tripler circuits, filtering (RC, RC π -section and LC section), voltage regulation and Zener generator, junction transistors, hybrid transistor parameters, load line analysis and biasing, transistor characteristic curves, single-stage transistor amplifiers (common base, common emitter, and common

collector), silicon-controlled rectifiers, silicon controlled switches, unijunction transistors, field effect transistors, use of a curve tracer, vacuum tube characteristics (triodes, pentodes, beam power tubes, load lines, common amplifier circuits).

FOURTH QUARTER

Laser Technology

Laser power and energy measurements, characteristics of flashlamps, discharge circuits, and pulse forming networks for optically pumped solid lasers, CW arc lamps and power supplies for CW lasers, cooling systems for CW-pumped solid lasers, safe operation and measurements with argon, CO₂, ruby, Nd:YAG, dye and semiconductor lasers, study of laser Q-switching with a ruby laser.

Experimental Optical Methods

Types and properties of optical materials, cleaning optical components, types of glass and glassworking equipment, glassforming operations, glass seals, vacuum systems, thermo-couple and ion gauges and gauge controllers, vacuum valves, cold traps, mechanical and oil diffusion pumps, evacuation and charging of vessels, vacuum deposition of thin films.

Technical Communications

Techniques of collecting data and organizing, writing, and editing technical reports, use of lab notebooks, preparation of equipment and component specifications.

Industrial Safety

General laboratory safety practices, chemical and electric hazards, and control measures, safe electrical wiring practices, toxic fumes, noise hazards, and personnel protection.

Solid State Circuit Analysis

Multi-stage transistor amplifier circuits, cascade amplifiers, decoupling, frequency response, transformer coupling push-pull amplifiers, complementary symmetry, DC amplifiers, chopper amplifiers, Darlington configuration, phase inversion, feedback fundamentals (negative feedback, current feedback, voltage feedback), feedback regulation for power supplies, series and shunt regulator circuits, positive feedback waveform generators, negative resistance waveform generators, tunnel diodes and circuits, UFT relaxation oscillator and staircase generator, characteristics of ideal operational amplifiers and common configurations, characteristics of real op-amps, practical circuits for voltage and current reference sources using op-amps waveform generator circuits using op-amps, integrated circuit op-amps.

FIFTH QUARTER

Laser/Electro-Optic Devices

Photodetectors, calorimeters and laser power meters, holographic equipment and supplies, techniques and setups for making holograms, photographic instrumentation including oscilloscope, SLR, and streak cameras and special purpose imaging devices, laser modulation and Q-switching devices including electro-optic, rotating prism, acousto-optic and bleachable dye methods, use of laser collimators and autocollimators, spatial filters, beam expanders and Faraday isolators.

Laser/Electro-Optic Measurements

Wavelength, dispersion and refractive index measurements with divided-circle prism/grating spectrometer, use of monochromators and spectrophotometers, use of scanning Fabry-Perot interferometer for observation of longitudinal modes in a laser output, use of fixed spacing Fabry-Perot etalon, Michelson interferometer, use of Twyman-Green interferometer in optical testing, use of Mach-Zehnder interferometer for measuring refractive index of a gas, spatial resolution, concept of the modulation transfer function (MTF), use of USAF 1951 resolution target to measure MTF of a lens.

Digital Circuits I

Introduction to digital measurements, biasing conditions of npn and pnp transistor switches, relays as switching elements, gating circuits, diode gate and coincidence circuits, AND gate, anticoincidence circuits using diodes, OR gate, transistor driven gate, NAND gate, classification of gates, digital IC's, diode logic, resistor-transistor logic, diode-transistor logic, direct coupled transistor logic, transistor-transistor logic, emitter coupled logic, flip-flops, bistable multivibrator circuit, gates, JK flip-flops, master-slave JKFF, monostable multivibrator, Schmitt trigger circuits and their applications.

Machine Tools and Shop Practice

Operation of engine lathe, milling machine, drill press, grinder, sheet metal cutter and bender, hole punch and band saw. Preparation of shop drawings, use of dimensional tolerances, familiarization of different fabrication materials, mechanical and chemical finishes.

SIXTH QUARTER

Laser Applications

Cutting, drilling and welding with a laser, air pollution monitoring with lasers, data processing and data display, optical memories, holographic non-destructive testing, medical applications of lasers, ranging and angle tracking, optical communications systems.

Laser Projects

Construction and testing of a laser, optical or electro-optic device such as a helium-neon laser. CW-pumped Nd:YAG laser, CO₂ laser, optical power meter, autocollimator, LED communications link or photomultiplier power supply. Maintaining a laboratory notebook.

Digital Circuits II

Numbering systems, binary, conversion codes including binary-coded decimal (BCD) system, octal, digital logic. Boolean algebra-symbols and properties, NOR gate and NAND gate, half-adder and full-adder circuit configurations, digital symbols, counters and registers, modulo N counters, analog to digital (A/D) and digital to analog (D/A) conversions, binary ladder resistor networks, multiplexing integrating op-amp as a D/A converter, digital readout devices, digital instruments including digital voltmeter (DVM), frequency synthesizer, phase frequency detector.

Introduction to Computer Hardware

Study and use of input/output (I/O) devices used with digital computers; interfacing and troubleshooting techniques, data acquisition and computer graphics.

Supportive Instructional Modules

The content of the LEOT instructional materials was determined by extensive analysis of task and essential skills lists for LEO technicians provided by members of the Industrial Advisory Committee and TERC staff. Use of the modular concept has a number of advantages. For example, both for the student and the instructor, it is beneficial to break the material in a given course up into learning units of reasonable size. Further, the specific student learning outcomes or behaviors are clearly stated at the beginning of each learning unit. This greatly increases learning incentives, especially if the tasks in the learning unit or module are job-oriented, i.e., relevant.

Accordingly, a series of laboratory centered laser/electro-optics instructional modules was developed, each module representing approximately one independent learning experience. The major divisions of these laser/electro-optics instructional modules are as follows:

Introduction, which identifies the topic and often includes a rationale for doing the exercises.

Objectives, which are stated in terms of action-oriented behaviors and which include such action words as operates, measures, calculates, identifies, and defines, instead of words with many interpretations such as know, understand, learn and appreciate.

Discussion, which presents the background theory and techniques supportive to the objectives of the lesson. This material must be well organized and free of extraneous and irrelevant material. Sentences are written clearly and concisely. Diagrams and illustrations are used to assist in supporting ideas and concepts.

Materials, which identifies the equipment required to complete the exercise.

Procedures, which is the experiment section or "hands-on" portion of the module. It includes step-by-step instructions. The experiments are designed to reinforce student learning, and data sheets for each experiment are provided in each module.

Problems, which are included for the purpose of reviewing and reinforcing the points covered in the exercise.

Reference Materials, which are included as supplementary reading/viewing for the student.

The modules have been tested with students and the results are very encouraging. Each module contains measurable objectives and a laboratory or "hands-on" experiment supportive to those objectives.

A list of titles of instructional modules follows, grouped by courses within the LEOT Model Curriculum.

Options

One option taken from the Model Curriculum consists of the following five courses, each of which consists of a pre-selected number of lessons or modules:

- Course 1. Introduction to Lasers
(11 modules)
- Course 2. Geometrical Optics
(11 modules)
- Course 5. Wave Optics
(11 modules)
- Course 6. Laser Electro-Optics Components
(11 modules)
- Course 9. Laser Projects
(7 modules - student selects only one)

These courses can be integrated into existing six-quarter programs in technological fields allied to laser technology. Examples include electronics, optics and vacuum technologies.

Using this option, an institution could move toward a full LEOT program by gradually developing faculty, and gradually increasing the number of students served. If a limited number of teaching personnel are available to initiate the laser electro-optics technology, the institution may broaden its technical staff gradually, and equipment expenditures for a full LEOT program can be distributed over several budget years.

It should be emphasized, however that a full LEOT program is not necessary to develop graduates trained with skills to enable him to be useful in the world of work. The Industrial Advisory Committee has verified that the five courses listed above, when included as an LEO option to a compatible electronics program produce technicians who are highly useful to industry; particularly in those companies or institutions where the laser or electro-optical device is incorporated as a component to a larger instrument or system (i.e., a radar system).

A second suggested option would involve the inclusion of several LEOT courses into an existing program in Technical Physics or Electro-Mechanical Technology (EMT). A graduate from one of these programs with a specialty in Laser/Electro-Optics would most easily find employment in applied research activities such as exist at several government and non-profit research institutions. The LEOT instructional modules which would integrate into these programs easily would be found in courses 1, 2, 4, 5 and 10 (see listing, page 2-13).

Other programs and courses to which the supportive instructional modules apply are known to include:

- Chemistry
- Civil Technology
- Construction Technology
- Industrial Technology
- Optical Technology

In addition, LEOT modules could easily be integrated into existing 4-year bachelor's degree programs in electrical engineering and applied physics.

MODEL CURRICULUM FOR AN ELECTRONICS TECHNOLOGY PROGRAM

WITH A

LASER ELECTRO-OPTICS TECHNOLOGY OPTION

COURSE	QUARTER PLAN				
	Hourse per week				Credit
	Class	Lab	Study	Total	
<u>First Quarter</u>					
Mathematics I	4	0	8	12	4
DC Circuits	3	3	6	12	4
Electronic and Mechanical Fabrication	1	3	2	6	2
Physics	3	3	6	12	4
Drafting	2	3	4	9	3
	<u>13</u>	<u>12</u>	<u>26</u>	<u>51</u>	<u>17</u>
<u>Second Quarter</u>					
Mathematics II	4	0	8	12	4
AC Circuits	3	3	6	12	4
Electro-Mechanical Controls	3	3	6	12	4
Industrial Safety	2	0	4	6	2
Introduction to Lasers	3	3	6	12	4
	<u>15</u>	<u>9</u>	<u>30</u>	<u>54</u>	<u>18</u>
<u>Third Quarter</u>					
Electronic Instrumentation & Calibrations	3	3	6	12	4
Semiconductor & Vacuum Tube Fundamentals	3	3	6	12	4
Machine Tools & Shop Practices	3	3	6	12	4
Geometrical Optics	3	3	6	12	4
	<u>12</u>	<u>12</u>	<u>24</u>	<u>48</u>	<u>16</u>
<u>Fourth Quarter</u>					
Solid State Circuit Analysis	3	3	6	12	4
Microwaves	3	3	6	12	4
Conversational Computer Languages	3	3	6	12	4
Laser Electro-Optic Components	3	0	6	9	4
	<u>12</u>	<u>9</u>	<u>24</u>	<u>45</u>	<u>16</u>
<u>Fifth Quarter</u>					
Digital Circuits I	3	3	6	12	4
Communications I	3	3	6	12	4
Wave Optics	3	3	6	12	4
Technical Communications	3	3	6	12	3
	<u>12</u>	<u>12</u>	<u>24</u>	<u>48</u>	<u>15</u>
<u>Sixth Quarter</u>					
Digital Circuits II	3	3	6	12	4
Communications II	3	3	6	12	4
Laser Projects	3	3	6	12	4
Introduction to Computer Hardware	3	3	6	12	4
	<u>12</u>	<u>12</u>	<u>24</u>	<u>48</u>	<u>16</u>

III. PROGRAM PLANNING

The purpose of this section is to provide information on LEOT program requirements for facilities, equipment, materials and staffing so that institutional planners can develop cost estimates for implementing a new program. The overall Model Plan described in this section is based on a class size of sixteen students, working in the laboratory in pairs on experiments. With proper scheduling of classrooms, labs and instructors time, three sections of students can be taught in a quarter, indicating a total unit program capacity of forty-eight students. The requirements for laboratory space, design and safety were suggested by the TERC, LEOT Industrial Advisory Committee and have been reviewed and verified by the TSTI and TERC staff.

The equipment needs and costs are based on the use of the TERC, LEOT supportive instructional modules. Cost savings made possible by cross-utilization of equipment in several courses are also included. Equipment lists and cost information for each of the ten courses in the LEOT Model Curriculum are provided in Appendix A, along with a total cost summary and a capital equipment usage matrix. Similar data is given for the LEOT Option Plan.

It is recognized that the costs of implementing a full program according to the Model Facilities and Equipment Plan may be prohibitively expensive in some cases. A series of alternatives to the Model Plan is provided which can result in significant savings to an institution particularly in the first few years of implementation while the program is "proving its worth".

Facilities

Facilities required for LEOT programs include classrooms, laboratories, staff offices, a student lounge area, glass shop, and library facilities. The following description is based on classes of sixteen students each, scheduled to allow for handling of up to three laboratory sections weekly for each class.

A high ratio of laboratory to classroom space is recommended, because the greatest amount of learning takes place in the laboratory where students have the opportunity to do things with real equipment.

No unusual utility services are required in LEOT classrooms. Duplex outlets should be provided for use of audio-visual aids and demonstration equipment. The service requirement need not exceed 30 amperes at 110 volts, 60 Hz.

The minimum classroom lighting level should be 70 foot candles, controllable from both the front and the rear of the room.

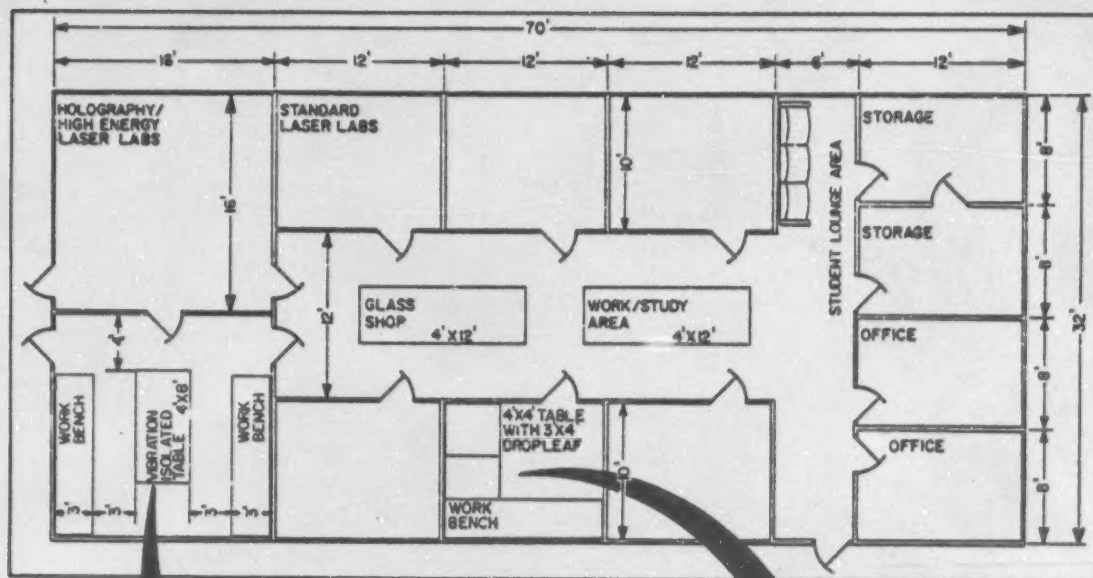
Staff office space should allow for about 100 square feet per teaching faculty member. There should be a limit of one person to an office so that counseling does not become awkward for the teacher or embarrassing to the student. Normally, several faculty members can share one secretary who will provide typing, clerical, copying, appointment and coordination services.

The laboratory requirements given here allow for implementation of the full LEOT program, but individual institutions may start up their LEOT laboratory facilities as adjuncts to existing electronics, optics, vacuum technology, or physics laboratories.

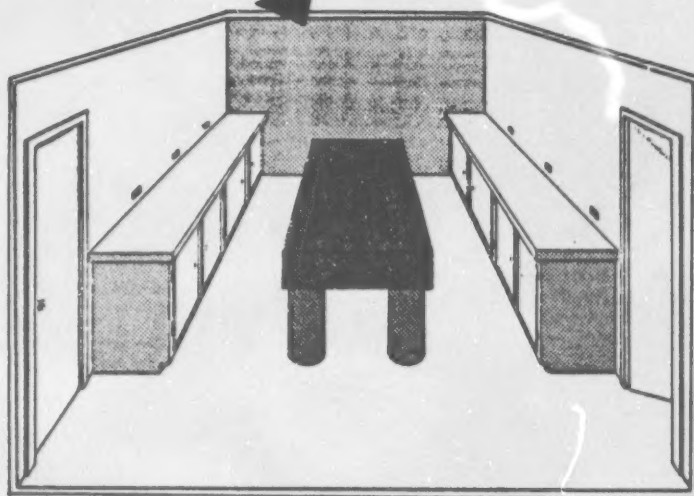
The TERC, LEOT Industrial Advisory Committee recommends, for a fully implemented program, about 80 square feet of laboratory space for each student, that is, a total of about 1300 square feet for the suggested class of sixteen. The laboratories should be windowless, painted a flat, light blue, and well lighted. The lighting level should be between 70 and 100 foot-candles, variable down to zero by means of dimmer controls.

Each laboratory bay should be equipped with safety lights, door interlocks and intrusion-control locks to ensure the protection of students, faculty and visitors. The arrangement of the total laboratory area should permit easy access for visitors, but should also prevent interference by them with student work and with equipment. There should be an easily accessible storage and control space for safety glasses near at least one entry point. Laser eye/skin hazards warning signs should be posted at each laboratory and high voltage warning signs should be labeled on individual equipment. A layout for the office-storage-laboratory area, and the details of a typical windowless bay are shown in Figure 3-1.

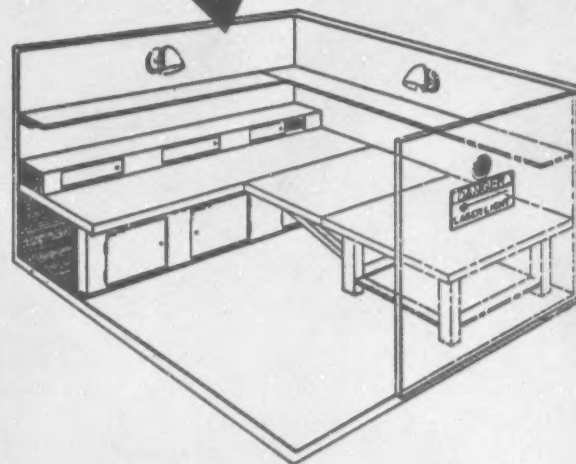
Two of the eight laboratories shown in Figure 1 provide a larger amount of floor space than the other six labs. This extra space is necessary to accommodate high energy lasers and ancillary equipment, high vacuum apparatus, holography setups and other optical experiments. One of these two labs should have a 4' x 8' vibration isolated table with the legs mounted on a solid foundation down to ground level (see LEOT Equipment List, Appendix A), while the other should include a 4' x 8' standard laboratory table. The area designated for the glass shop should include a long workbench with gas tanks, cabinets for storing glassworking tools, torches and burners, and a separate cabinet for storing and sizing glass tubing and rods.



Ⓐ LASER LABORATORY FLOORPLAN



Ⓑ HOLOGRAPHY/HIGH ENERGY LASER LAB



Ⓒ STANDARD LASER LAB

Fig. 3-1. Suggested Laboratory Facility

Equipment

Most of the LEOT program laboratory experiences will require routine optics and laser laboratory hardware such as low-powered helium-neon gas lasers, optical benches and component supports, lenses, filters, and photodetectors. A few complex systems are necessary, for example, a Q-switched ruby laser system, argon laser, ballistic thermopile acousto-optic modulator, and Nd:YAG laser. All students should be exposed to some complex equipments and intricate systems during the second year of laboratory use. These experiences will prepare the students for initial industrial equipment encounters, developing confidence with equipment and systems and respect for them.

Equipment requirements are given in Appendix A. This equipment can be acquired gradually or at one time, depending on the individual institution's program-development plan. The supportive instructional modules have been developed to allow for sharing items in multi-sectioned laboratories, items whose use in this manner will not interfere with the student's learning experience. Module design also allows for sharing items in multi-sectioned laboratories, items whose use in this manner will not interfere with the student's learning experience. Module design also allows for sharing of those expensive capital items whose total cost might deter an institution from building a strong program by acquiring them.



Fig. 3-2. Students modulating an argon laser by use of an electro-optic device. (TSTI, Waco)

Staffing

Program planning and implementation for the complete TERC/LEOT program can normally be done by two skilled instructors. Such instructors should have a strong background in lasers, applied optics and electronics. Experience in laser applications is very helpful when such a person can be found.

Because of the severe demand in some parts of the country for highly-qualified laser scientists, engineers and technologists, laser expertise might have to be developed through the loan of an expert by a local laser manufacturer or laboratory. Such persons often enjoy teaching and planning, and frequently donate much valuable time and advice beyond their level of remuneration. In addition, goodwill between technical educators and potential employers is enhanced by this procedure. Additional information on staffing is provided in a later section entitled "Program Implementation."

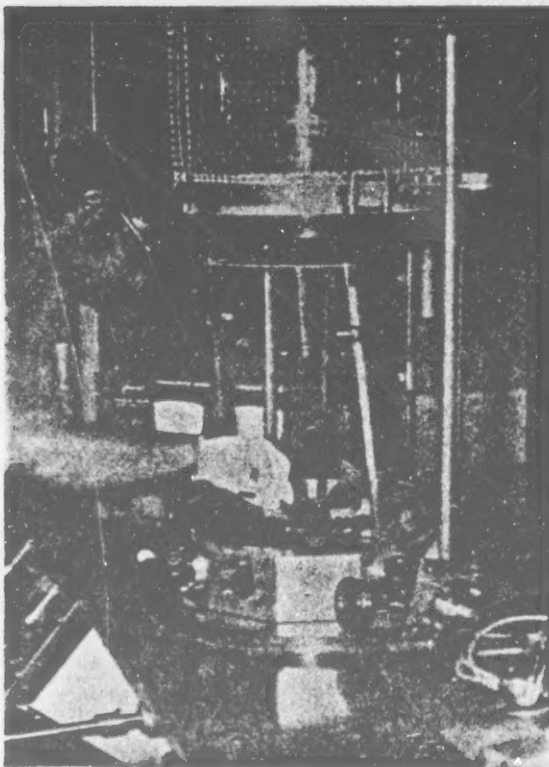


Fig. 3-3. Students working in laboratories at San Jose City College.

Costs

For an institution to ascertain the cost of implementing the LEOT program, an inventory of existing equipment must be made and compared against the capital and non-capital items listed in the Equipment List (see Appendix A) and in each module. Cross-module comparisons will effect a cost savings for the total program. Appendix A contains an Equipment Cost Summary for the complete 10-course, TERC/LEOT program as well as for the 5-course LEOT Option Plan.

All of the equipment is not used in the first year of the program as described for the Model Plan. In fact, only about one-third of the equipment costs need to be incurred the first year. The following chart describes incurred equipment costs per quarter for a full two year LEOT program.

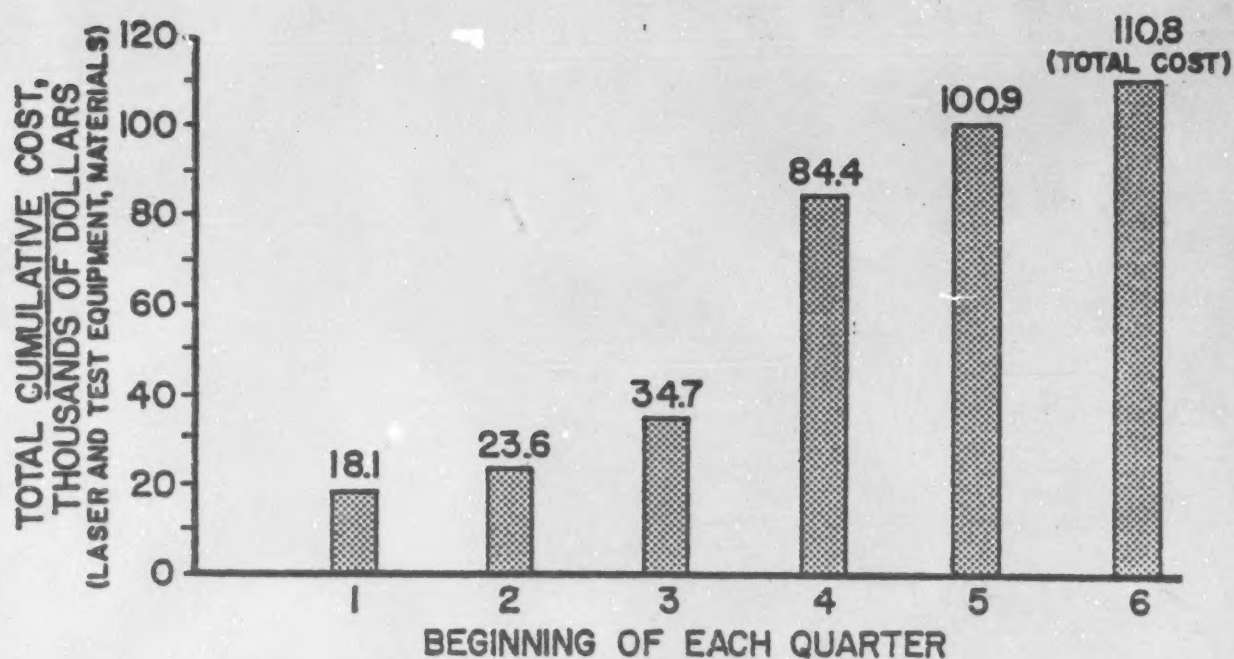


Fig. 3-4. Cumulative equipment costs by quarter incurred for a new two year LEOT program.

Program Alternatives to Reduce Cost

In certain cases the total cost of the TERC/LEOT Program, using the suggested model facilities and equipment which are described in Appendix A, may seem prohibitive. Some suggestions for reducing costs are presented in this section. These ideas have been tried and proven in other institutions. The ingenuity of local institutional planners and faculty will no doubt suggest others.

1. **LEOT Option Plan:** The Option Plan discussed in Section 2 may be used in two ways. First, where the full ten course LEOT Program cannot be implemented due to its total cost or other reasons, the five-course Option can be implemented for about one-third the cost of the full program. An examination of the Equipment List in Appendix A shows an unusually high amount of cross-utilization of equipment among the Option Plan courses. The courses comprising the LEOT Option Plan have been specifically chosen, with the advice of the TERC Industrial Advisory Committee, so as to also produce a person with desirable entry level skills and training in laser/electro-optics. For example, personnel involved with one of the many applications of lasers or optics in related fields, such as electronics do not need all of the skills required by technicians whose primary duties are concerned with development and operation of high-energy lasers.

Another use of the Option Plan is to precede the full program several years. If the full ten-course LEOT Program is to be used, the Option Plan courses could be implemented first in order to spread the capital outlay of funds over a longer period of time.

2. **Individualized instruction and open labs:** The TERC/LEOT modules are particularly amenable to adaptation into an individualized instruction or programmed learning format. This would make maximum use of instructor time, as well as allowing students to move at their own pace. A number of modules have already been individualized by institutions who have implemented the LEOT Program or Option Plan thus far.

The use of open labs can also help reduce costs by decreasing the number of laboratory setups needed for a single module. In this regard it should be mentioned that the number of capital and non-capital items listed for each course in the Equipment List is based upon a class of sixteen. Ideally, two-man lab teams should

be used (i.e., lab setups per experiment for one lab section). Thus, if only eight students are anticipated for a given course, the number of lab setups can be decreased by half, etc.

3. In-house equipment fabrication: A side-benefit of student project courses in lasers and optics is the fact that, in many instances the finished projects (e.g., He-Ne lasers, optical power meters, mirror mounts, etc.) can be used for lab experiments in other courses. The technical members of the Industrial Advisory Committee can frequently be of immense help in designing equipment for student projects, and through equipment loans or donations of used equipment. In addition, all of the project modules in Course #9 will yield equipment supportive to modules in earlier courses. Much useful equipment can be obtained at minimal cost (often just transportation costs) through state and federal surplus property agencies, and through used equipment grant programs available in governmental agencies. It is important for the institution, if possible, to have one person whose assignment is to be aware of and seek out sources of surplus and excess property.
4. Avoid teaching all of the modules requiring expensive equipment. (These are usually highly specialized modules on specific laser systems.) When local task analysis shows that one of those modules must be taught, try to borrow sophisticated laser systems or use industrial lab facilities. In some cases close cooperation with industry can lead to in-house laser training programs and co-op programs of mutual benefit.
5. Laboratory facilities: Instead of constructing the model laser laboratories shown previously, consider an inexpensive conversion of existing physics, chemistry, general science and electronics technology laboratories for use as laser/optics labs. An example of how a physics lab was thus converted is shown in the photograph, (page 3-9) which was taken at the Harlingen campus of Texas State Technical Institute. The lab carrels (two-man work stations) have individual light dimmer controls to provide variable illumination needed in many experiments. The partitions are easily constructed with economical materials. No special wiring or auxiliary facilities are required. Note also that the addition of these partitions, etc., did not significantly reduce the effectiveness of the facility for teaching physics. In fact, at this facility, a physics lab is taught one day and a laser lab the next.

6. Use of student aides: Instead of hiring two instructors initially to implement the LEOT Program or Option Plan, one instructor can be utilized if he has the help of work/study students and lab assistants.
7. Library facilities: Books, journals and films for the LEOT Program (see Appendix B) may be acquired gradually. The references listed at the end of each TERC module serve as a guide for planning library acquisitions for each course.

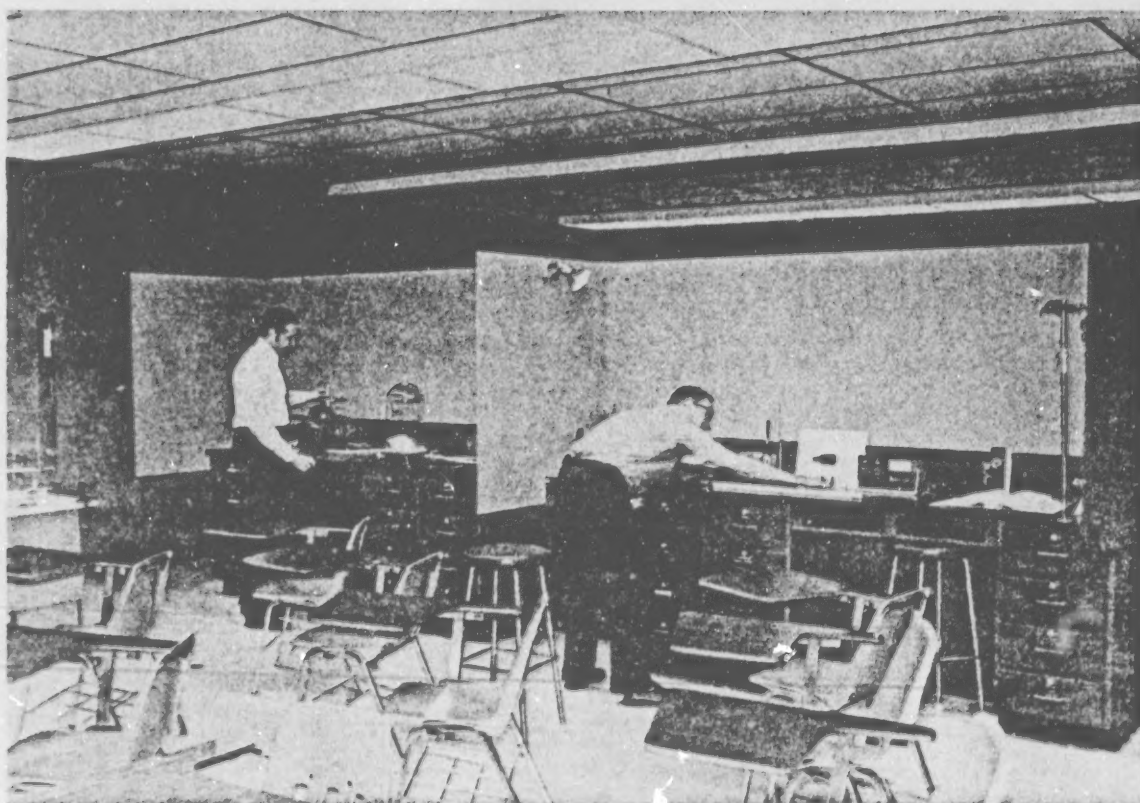


Fig. 3-5. Converted physics laboratory used as a laser facility at TSTI, Harlingen.

IV. PROGRAM IMPLEMENTATION

The following eleven steps represent a logical development procedure for an institution planning to implement a LEOT program:

1. Locate interested industries and laboratories in the local area which would hire LEOT technicians. Assemble an Industrial Advisory Committee.
2. Conduct a survey to determine the number of LEOT technicians which will be needed in the next five years.
3. Meet with the Industrial Advisory Committee to determine the specific training needs for employment of entry level LEOT technicians by local industries.
4. Reconfirm the decision and commitment of the institute to implement the program.
5. Select a Program Coordinator or Department Chairman. Obtain a suitable faculty.
6. Recruit students to enter the program when it opens.
7. Develop the LEOT curriculum, select instructional materials and the support courses which will be needed.
8. Acquire appropriate facilities and equipment.
9. Train the instructors.
10. Initiate the Pilot Program.
11. Meet with the IAC, evaluate the program and revise it.

Additional information which may be beneficial in achieving a successful program implementation will be found in this section.

Industrial Advisory Committee

Institution planners must have the following information before they implement an LEOT program:

1. Job opportunities in the region for program graduates.
2. Employer needs and technical specialties local industries which will support the program.
3. Hands-on skills necessary for entry level jobs.
4. Salary scales for the field(s).

This information can be obtained and used most effectively through the establishment of an Advisory Committee. A LEOT Advisory Committee should include members of the community who are interested in technical education, staff members of the institution, educational consultants from firms such as TERC, and most important, potential employers of graduate technicians. Members are usually appointed by the institution's chief administrator or dean, for no less than one and no more than three years. The committee should meet frequently during the program implementation stages and once or twice per year after the program is established.

The selection of industrial members of an advisory committee should be based upon the recommendation of one of the company's executives. This provides some assurance that the company recognizes and is committed to support the program. Industrial members should preferably be the company's first-line technical supervisors. The supporting companies should be kept informed of the committee's progress, and they should be publically thanked for their efforts on behalf of the institution.

The committee evaluates and sometimes assists in gathering the information listed above; estimates the available student population; guides decisions regarding curriculum, faculty, and laboratory facilities, giving initial approval to an appropriate curriculum, helping institution staff members find teachers, and determining cost ranges for facilities and equipment. Committee members can assist in loaning or donating surplus equipment for the new program.

Frequently an advisory committee can be very helpful in applying for grants of local, state and federal funds to support program implementation. And when graduates seek employment, committee members can aid them in placement and evaluation of their performance. These evaluations often result in minor modification to the program, bringing it more closely in line with employer needs.

Functions of an Advisory Committee

1. Identification of potential LEOT employers.
2. Assistance in a local needs survey (see Appendix D), by preparing a unique survey to fit the local situation. Contacting key executives to ensure active participation by industry.
3. Evaluation of documented local needs and skills to determine their impact on LEOT program design.

4. Solicitation of potential students - high school graduates, discharged military personnel, and local employees capable of using more training.
5. Assistance to faculty and placement officers in finding full-time entry-level positions for graduates, and cooperative work-experience programs for current students.
6. Guidance in the selection and acquisition of appropriate laboratory equipment to ensure relevant training and a smooth transition from laboratory experience to the job environment.

Many industries are currently employing technicians for LEOT work who are not adequately trained. This represents an immediate training need of industry which can often be met by the institution initially providing courses for retraining (or sometimes called "retreading" existing employees. Courses such as these, if provided, can show industry the responsiveness of the institution and the quality of the LEOT training, which should have a positive effect on enlistment of support from Industrial Advisory Committee members.

Instructional Methodology

The instructional materials which have been developed for this program place heavy emphasis on the practical - not the theoretical. Theoretical texts on lasers and books on laser applications are abundantly available at this time. However, even in a technology as sophisticated as LEOT it is not only possible but necessary to teach technicians methods and techniques instead of theories and derivations. This same emphasis on learning objectives should be conveyed by the LEOT instructor as well as in the texts. To further illustrate this point consider the following two examples:

- o "More important than learning the theory of dielectric laser reflection in optical filters is to learn principles which show when it is appropriate to use a filter which only costs \$0.50 and when one should select and/or purchase one which costs \$500.00."
- o "It is more important for a LEO technician to know how to clean mirrors and align a laser cavity than it is to derive the theory of modes in an interferometric resonator."

As a further example, recall that the math required for understanding the LEOT instructional modules is limited to algebra and simple trigonometry.

As a consequence of the emphasis upon principles, skills, methods, and techniques the suggested primary method of instruction is laboratory centered learning, i.e., "learning by doing". The instructional materials for the Laser/Electro-Optical Technology have been developed and tested at the technician level. They have been approved by industrial representatives that actually hire LEOT technicians. Each instructional module contains performance objectives, the discussion, and a laboratory activity that exemplifies the principles outlined in the discussion.

The benefits to be gained through performance objective analysis make the effort worthwhile. This type of analysis makes possible an exact specification of the demand of each entry-level job, and of the training paths necessary for the student to qualify as a laser or electro-optical technician, or as a worker in a related field.

A faculty coordinator should be selected and briefed about the LEOT program. TERC staff and people from institutions which have used the program can be very helpful here. The faculty coordinator should be capable of bringing existing faculty members together as a cohesive working group, so that courses will be taught as bridges to one another, rather than as unconnected islands of subject matter. The interests and capabilities of faculty members must extend beyond their specialties, or the spirit which attracts and draws out highly motivated students will be lost.

Teaching materials - including auxiliary aids, texts, and references - must be kept up-to-date with developments in the field, and with research in support areas, and communications skills. Instructors should make a practice of reviewing new texts and other teaching materials as they appear, with regard to both content and methods. The list of suggested texts and other teaching materials which have been included in this guide (Appendix B) is not meant to be all-inclusive.

The TERC LEOT instructional modules were developed to fill the gap between highly theoretical texts and trade journal articles and application notes. Designed to be self-contained, modules are grouped into courses as noted on page 2-2. Each of these courses is also self-contained. The modules have been prepared to provide for either individualized instruction or sequenced lecture-laboratory exercises. Each module consists of an experiment whose measurable objectives should be accomplished as presented.

Staffing

The competence and enthusiasm of the teaching staff are major factors in the success of an LEOT program. Ease in handling technical subject matter and understanding the problems of industry are at least as important as teaching

experience. Technical education is unique in its integrated theoretical and practical approach. The teaching staff should be aware of this.

Each faculty member should be familiar with the full range of skills and knowledge that an LEO technician is expected to have at his/her disposal. For instance, an electronics teacher who is familiar with the program's communications skills requirements will be able to exemplify them in his oral and written presentations.

Once a faculty coordinator has been chosen, staff selection begins with the identification of applicants who have skills in optics, lasers, electronics and instrumentation. Ideally, at least one member of the LEOT faculty should have worked in a laser and/or electro optic industry or laboratory for at least three years. However, engineers or physicists with this type of experience are earning very high wages and it would be a rare experience to find one, with enough commitment to technical education which would leave his profession to enter teaching. If a faculty member cannot be obtained with the requisite experience in laser/electro-optics then it is suggested that existing faculty members in electronics or physics be employed on the LEOT staff and that practicing engineers or physicists be used to teach on a part time basis.

Potential faculty members should be aware of all the advantages to the program to be gained in having strong industrial ties. Ability to work with others is very important, as it guarantees a sense of continuity, as students move from course to course. The model program has been designed for successful implementation with minimal faculty coordination, but without it, there is less probability of maintaining student motivation and enthusiasm; and these qualities are very important to potential employers.

Course loads from 15 to 20 contact hours per week will permit faculty members to maintain and update their technical capabilities, which is extremely vital in this rapidly developing and changing technology. It is suggested that faculty members take frequent visits to industrial sites and one quarter sabbaticals every two years for the specific purpose of working in laser and electro optic industries or government labs. Some funds for travel, study, and allocations for time off will be necessary if this is to be accomplished.

Staff orientation can be carried out within the institution, or in cooperation with other schools. Professional societies (Appendix B) and organizations like TERC can help institutions prepare and implement in-house faculty training programs.

Evaluation

The individuals who are responsible for the planning, development and implementation of an LEOT program should feel accountable to students, industry and the educational institution for high quality program that will train men and women for useful work. Training evaluation involves quality control procedures for, and is an integral function of training development, modification, revision and improvement. Continuous evaluation of the program is necessary to assure that the project objectives are accomplished. It includes a systematic procedure and checkpoints to assure relevancy, appropriateness, substance and teaching effectiveness.

The final evaluation of a technology program is the graduate's success at finding one or more jobs that have advancement opportunities - and given this, the employer's satisfaction with the technical and social abilities of the employee. All other evaluation criteria fall in line behind these two.

It would certainly be dangerous for the administrators of an LEOT program to put off judging its effectiveness until the first two-year course was completed. Accordingly, especially for the new program, "input" and "process" evaluations are equally as important as "output" measures. Input evaluation can be performed by measuring program elements against industrial needs. Process evaluation allows faculty and staff to do everything they can to improve the program even as it is being taught for the first time.

Three elements of process evaluation are analysis of the objectives - are they consonant with industrial needs at each step of the way? - the curriculum materials and equipment - are they supportive and relevant to accomplishing the objectives? - and instructional methods - are they efficient in developing students' knowledge and skills?

Feedback information should be gathered from all available sources throughout planning, implementation and placement. Every participant, students, faculty, staff and advisory personnel, should be involved in the evaluation process. Another evaluation technique, which may be a part of a regular followup system, is a periodic review of the program by employed graduates. Such a review provides positive feedback by relating the program content to occupational needs. Feedback from graduates is especially valuable in making program changes that incorporate new technological developments.

LEOT CURRICULUM GUIDE APPENDICES
(Not included in this report)

APPENDIX A
EQUIPMENT LIST SUMMARY
FOR LEOT MODULE CURRICULUM

APPENDIX B
REFERENCES

APPENDIX C
MODEL SURVEY QUESTIONNAIRE

APPENDIX D
LASER ELECTRO-OPTICAL TECHNICIAN PROGRAM
MATERIALS AND SERVICES

APPENDIX B

**"Laser-Electro/Optics Technology Instructional Materials" and
"Laser - Electro / Optics Technology"
Pamphlet**

Laser/Electro-Optics Technology Instructional Materials



TECHNICAL EDUCATION RESEARCH CENTER-SW
4201 LAKE SHORE DRIVE, SUITE 111
WACO, TEXAS 76710

The Laser and Electro Optics modules listed in this brochure were prepared by the Technical Education Research Centers under a Grant from the U. S. Office of Education. The purpose of the program is to develop curriculum and instructional materials to prepare Laser and Electro Optical Technicians at two year, post secondary technical schools. However, the modules are also being used by engineering schools, in continuing education short courses, in industry for "in house" training programs, by individuals for self study, and as practical, technical reference materials.

Approximately one hundred modules have been developed, each with measurable learning objectives that are related to specific tasks and principles needed "on the job". These tasks were obtained from a team of employers of laser personnel. The material is presented in such a way that a reader may understand it with prerequisites of only algebra, trigonometry, and minimal physics and electronics. Although the modules are conveniently grouped together into courses, most of them are relatively independent and may be used separately or in other groupings.

TERC has also developed instructional materials in the following technologies:

- Electro-Mechanical
- Bio-Medical Electronics
- Electronic Component Analyses
- Technical Physics
- Nuclear Technology

The Laser/Electro-Optics instructional modules may be purchased * for \$3.00 per single copy or \$2.50 when purchased in courses.

Daniel H. Hull, General Manager
Technical Education Research Centers

COURSE 1. INTRODUCTION TO LASERS

UNIT I LASER FUNDAMENTALS

- MODULE 1 - 1 ELEMENTS AND OPERATION OF A LASER
- MODULE 1 - 2 OPERATION OF AN OPTICAL POWER METER
- MODULE 1 - 3 WAVE PROPERTIES OF LIGHT
- MODULE 1 - 4 INTRODUCTION TO LASER SAFETY

UNIT II LASER PHYSICS

- MODULE 1 - 5 ENERGY LEVELS IN ATOMS
- MODULE 1 - 6 LASING ACTION
- MODULE 1 - 7 OPTICAL CAVITIES AND MODES OF OSCILLATION

UNIT III PROPERTIES OF LASER LIGHT

- MODULE 1 - 8 COHERENCE
- MODULE 1 - 9 POWER AND DIRECTIONALITY

UNIT IV LASER SYSTEMS

- MODULE 1 - 10 HELIUM-NEON GAS LASER - A CASE STUDY
- MODULE 1 - 11 LASER CLASSIFICATIONS AND OPERATING MODES

"Introduction to Lasers" consists of eleven modules. The first ten modules are designed to introduce the new student to the operation of a laser, the principles of a laser, its output characteristics, and safe operating practices. These modules are all taught using low power, helium-neon lasers. The last module surveys the various types of laser according to the active materials, output characteristics and applications.

Price: per course \$27.50

per module \$ 3.00

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COURSE 2. GEOMETRICAL OPTICS

UNIT I. INTRODUCTION TO GEOMETRICAL OPTICS

MODULE 2 - 1 REFLECTION AND RAY TRACING AT
PLANE AND SPHERICAL SURFACES

MODULE 2 - 2 PRINCIPLES OF REFRACTION

MODULE 2 - 3 REFRACTION AND RAY TRACING AT
PLANE AND SPHERICAL SURFACES

UNIT II. OPTICAL COMPONENTS AND SYSTEMS

MODULE 2 - 4 IMAGING WITH A SINGLE LENS

MODULE 2 - 5 IMAGING WITH A MULTIPLE LENS

MODULE 2 - 6 F-STOPS AND APERTURES

MODULE 2 - 7 OPTICAL SYSTEMS

MODULE 2 - 8 MATRIX OPTICS

There are three different methods for determining what happens to light as it impinges on a surface or boundary separating two optical media. The first method involves an application of the laws of reflection and refraction which enable the student to trace mathematically a ray of light reflected from and transmitting through a surface. The second method of determining how a ray of light will be reflected and refracted is a relatively simple and elegant technique known as Graphical Ray Tracing. This technique requires no mathematical or analytical solutions and can be extended to more complicated systems. It will in many cases provide an insight into how light propagates through complicated optical systems. The third method is the experimental technique in which the student will experimentally trace a ray of light through an optical system.

It is the intent of this course to provide the student with the mathematical ability, the knowledge to employ the graphical ray tracing techniques, and the experimental expertise to trace a ray of light through a system using any one of these techniques for a large variety of optical systems.

Price: per course \$20.00

per module \$ 3.00

COURSE 3. LASER TECHNOLOGY

UNIT I. LASER COMPONENTS AND MEASUREMENTS

- MODULE 3 - 1 PULSED LASER FLASHLAMPS AND POWER SUPPLIES
- MODULE 3 - 2 POWER SOURCES FOR CW LASERS
- MODULE 3 - 3 CW SOLID LASER - EFFICIENCY AND COOLING
- MODULE 3 - 4 LASER POWER AND ENERGY MEASUREMENTS
- MODULE 3 - 5 LASER BEAM DIVERGENCE AND FOCUSING

UNIT II. LASER SYSTEMS

- MODULE 3 - 6 ION GAS LASERS
- MODULE 3 - 7 MOLECULAR GAS LASERS: PRINCIPLES AND OPERATION
- MODULE 3 - 8 CO₂ LASERS AND PARAMETERS
- MODULE 3 - 9 OPTICALLY PUMPED CW SOLID LASERS
- MODULE 3 - 10 OPTICALLY PUMPED, PULSED SOLID LASERS
- MODULE 3 - 11 LASER Q-SWITCHING - GIANT PULSES
- MODULE 3 - 12 ORGANIC DYE LASERS
- MODULE 3 - 13 SEMICONDUCTOR LASERS
- MODULE 3 - 14 LASER SAFETY - HAZARDS EVALUATION
- * MODULE 3 - 15 LASER SAFETY - EFFECTS OF LASERS ON THE HUMAN BODY

* BEING DEVELOPED

The Laser Technology course explores in depth six specialized groupings of lasers. These six modules are independent of each other and a selection of any one or a group of them can be taught for a more specialized course. An understanding of these modules presupposes knowledge of laser fundamentals, output parameters and safety, as covered in Course 1 "Introduction to Lasers".

Price: per course \$35.00

per module \$ 3.00

COURSE 4. EXPERIMENTAL OPTICAL METHODS

UNIT I. OPTICAL MATERIALS

MODULE 4 - 1 TYPES AND PROPERTIES OF OPTICAL MATERIALS

MODULE 4 - 2 LIMITATIONS AND TESTING OF OPTICAL MATERIALS

MODULE 4 - 3 CLEANING OPTICAL COMPONENTS

UNIT II. GLASS FABRICATION

MODULE 4 - 4 GLASSES AND GLASS WORKING EQUIPMENT

MODULE 4 - 5 GLASS FORMING OPERATIONS

MODULE 4 - 6 GLASS SEALS

UNIT III. VACUUM TECHNOLOGY

MODULE 4 - 7 VACUUM SYSTEMS

MODULE 4 - 8 EVACUATION AND CHARGING OF LOW-PRESSURE DEVICES

MODULE 4 - 9 VACUUM DEPOSITION OF THIN FILMS

Course #4 is designed to provide the student with skills and fundamental knowledge of optical materials, glassworking and vacuum systems. The laboratory experiments in the modules were developed to be used with simple, inexpensive equipment.

Modules 1, 2, and 3 describe the various types of optical materials (glass, crystal, and plastics) their properties, proper care and cleaning techniques. The modules can be taught independently or as a unit. Modules 4, 5, and 6 should be taught serially as a unit. Completion of this unit will enable the student to produce usable glass forms, tubing bends, seals and repairs as well as a familiarization of the types of service he can expect from a scientific glass shop.

Module 7, 8, and 9 should also be taught serially as a unit. This series is designed to expose the student to the practical laboratory techniques of vacuum systems and thin film deposition.

Price: per course \$22.50

per module \$ 3.00

COURSE 5. LIGHT SOURCES AND WAVE OPTICS

UNIT I. GENERATION AND MEASUREMENT OF LIGHT

MODULE 5 - 1 SOURCES AND THEIR CHARACTERISTICS

MODULE 5 - 2 RADIOMETRY AND PHOTOMETRY

UNIT II. WAVE OPTICS

MODULE 5 - 3 WAVE NATURE OF LIGHT

MODULE 5 - 4 REFLECTION AND REFRACTION

MODULE 5 - 5 PROPAGATION

MODULE 5 - 6 INTERFERENCE

MODULE 5 - 7 DIFFRACTION

MODULE 5 - 8 POLARIZATION

UNIT III. SPECIAL APPLICATIONS OF WAVE OPTICS

MODULE 5 - 9 HOLOGRAPHY

Course #5 consists of nine modules. The first two modules consider the generation and measurement of light, including the fundamental origin of light, different types of light sources, spectral characteristics of light sources, radiometry and photometry. The next six modules are concerned with the wave nature of light, which is in sharp contrast to the Geometrical Ray Nature of Light treated in Course #1. These modules consider reflection, refraction and propagation of light from the view-point of wave optics. They treat the essential principles of Interference, Diffraction and Polarization of Light, all wave phenomena and all important to a sound understanding of Laser/Electro-Optics Technology. The final module in this course applies the principles of wave optics to the science of Holography.

Price: per course \$22.50

per module \$ 3.00

COURSE 6. LASER AND ELECTRO-OPTIC COMPONENTS

UNIT I. SUPPORT HARDWARE FOR OPTICAL COMPONENTS

MODULE 6 - 1 OPTICAL TABLES AND BENCHES

MODULE 6 - 2 COMPONENT SUPPORTS

UNIT II. LASER AND ELECTRO-OPTIC COMPONENTS

MODULE 6 - 3 PHOTOGRAPHIC COMPONENTS & SUPPLIES

MODULE 6 - 4 WINDOWS AND FLATS

MODULE 6 - 5 MIRRORS AND ETALONS

MODULE 6 - 6 FILTERS AND BEAM SPLITTERS

MODULE 6 - 7 PRISMS

MODULE 6 - 8 LENSES

MODULE 6 - 9 GRATINGS

MODULE 6 - 10 POLARIZERS

MODULE 6 - 11 NON-LINEAR MATERIALS

* MODULE 6 - 12 FIBER OPTICS

* MODULE 6 - 13 ELECTRO OPTICAL DISPLAYS

* BEING DEVELOPED

Course #6, Laser and Electro Optical Components, deals with the "tools of the technology". The modules in this course do not attempt to explain theories or principles, but instead describe the hardware that is available, how to determine the quality of a component that is required, and how to acquire it. As an example: the module on lenses only briefly reviews the principles of refraction with curved surfaces (so that the module is not dependent upon prerequisite modules), then goes into detail of the various aberrations that can be caused in lenses, the variety of lenses that are available and when they should be used. In the module on Filters, the emphasis is upon performance and cost, so that the technician will know when he can use a 50¢ filter and when he needs one that costs \$500.00. The ideas which are conveyed are intended to provide the student the benefits he would ordinarily derive only from years of practice in the laboratory.

Each module in the course is independent of the others, and can be taught separately or in any sequence.

Prices: per course \$27.50

per module \$ 3.00

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COURSE 7. LASER/ELECTRO-OPTIC DEVICES

UNIT I. OPTICAL DETECTION DEVICES

MODULE 7 - 1 PHOTODETECTORS

MODULE 7 - 2 LASER POWER & ENERGY DETECTORS

UNIT II. PHOTOGRAPHIC TECHNIQUES

MODULE 7 - 3 PHOTO INSTRUMENTATION EQUIPMENT

MODULE 7 - 4 HOLOGRAPHIC TECHNIQUES AND EQUIPMENT

UNIT III. LASER BEAM MANIPULATORS

MODULE 7 - 5 COLLIMATORS AND AUTOCOLLIMATORS

MODULE 7 - 6 BEAM EXPANDERS AND SPATIAL FILTERS

MODULE 7 - 7 ISOLATORS

UNIT IV. MODULATION DEVICES AND Q-SWITCHING

MODULE 7 - 8 MECHANICAL AND BLEACHABLE DYE METHODS

MODULE 7 - 9 ELECTRO-OPTIC MODULATORS

MODULE 7 - 10 ACOUSTO-OPTIC DEVICES

MODULE 7 - 11 MODE LOCKING

These modules cover the theory and operation of special purpose devices to measure laser output parameters, to manipulate laser beams and to modulate or Q-switch lasers. Also included are special techniques in Photography and Holography.

Module 7-2 is understood much better if it is preceded by Module 7-1. With this exception all the modules in course seven are relatively independent of each other, which provides the flexibility of selecting isolated modules to develop a course of special needs and interests.

Price: per course \$27.50

per module \$ 3.00

COURSE 8. LASER APPLICATIONS

UNIT I. MATERIALS PROCESSING

MODULE 8 - 1 WELDING

MODULE 8 - 2 DYNAMIC CUTTING AND DRILLING

UNIT II. DATA PROCESSING

MODULE 8 - 3 DATA RECORDING AND MANIPULATING

MODULE 8 - 4 DATA DISPLAY

UNIT III. TESTING AND MONITORING

MODULE 8 - 5 ENVIRONMENTAL TESTING & MONITORING

MODULE 8 - 6 NONDESTRUCTIVE TESTING

UNIT IV. RANGING AND ANGLE TRACKING

MODULE 8 - 7 RANGEFINDING

MODULE 8 - 8 ALIGNMENT AND ANGLE TRACKING

UNIT V. MEDICAL APPLICATIONS

MODULE 8 - 9 LASERS IN MEDICINE, SURGERY AND DENTISTRY

UNIT VI. COMMUNICATIONS

MODULE 8 - 10 LASER COMMUNICATION SYSTEMS

UNIT VII. CONSTRUCTION APPLICATIONS

MODULE 8 - 11 LASERS IN CONSTRUCTION

Course #8 consists of eleven modules, arranged in seven units of related modules. The purpose of Course #8 is to describe some of the laser applications that are emerging from the laboratory and coming into practical use in industry. The course will also provide training for the student in these applications.

Price: per course \$27.50

per module \$ 3.00

COURSE 9. LASER PROJECTS

UNIT I. LASER/ELECTRO-OPTIC SYSTEMS

MODULE 9 - 1 OPEN-CAVITY HELIUM-NEON LASER

MODULE 9 - 2 COMMUNICATIONS LINK

MODULE 9 - 3 CW PUMPED Nd:YAG LASER

MODULE 9 - 4 CARBON DIOXIDE LASER

UNIT II. ELECTRO-OPTIC DEVICES

MODULE 9 - 5 AUTOCOLLIMATOR

MODULE 9 - 6 POWER SUPPLY AND CALIBRATION
OF A PHOTOMULTIPLIER

MODULE 9 - 7 OPTICAL POWER METER FOR CW LASERS

Course #9 consists of seven modules whose end product is a series of working, student-built lasers and electro-optic devices. These modules are designed to expose the student to a wide variety of materials, fabrication and calibration methods, and measurement techniques used in a typical LEO work environment. Although design information for various parts of a given device (e.g., mirror mounts for a CO₂ laser) is provided in the appropriate module, the student should be encouraged to use his own ingenuity in solving design problems.

The importance of keeping an accurate laboratory notebook is stressed in these modules. The supplementary module on Laboratory Notebooks is a general prerequisite for Course #9.

The student should meet with his instructor at specified intervals to advise him of progress (and problems) on the various major tasks (milestones) involved in the project. In addition, a roundtable discussion on all student projects, once a week, is a helpful outlet in airing difficulties encountered, in generating ideas for solving problems, and in stimulating interest.

Price: per course \$17.50

per module \$ 3.00

COURSE 10. LASER/ELECTRO-OPTIC MEASUREMENTS

UNIT I. SPECTRAL MEASUREMENTS

MODULE 10 - 1 SPECTROMETERS

MODULE 10 - 2 MONOCHROMATORS

MODULE 10 - 3 SPECTROPHOTOMETERS

UNIT II. INTERFEROMETRIC MEASUREMENTS

MODULE 10 - 4 MICHELSON INTERFEROMETER

MODULE 10 - 5 FABRY-PEROT INTERFEROMETER

MODULE 10 - 6 TWYMAN-GREEN INTERFEROMETER

MODULE 10 - 7 MACH-ZEHNDER INTERFEROMETER

UNIT III. SPATIAL RESOLUTION

MODULE 10 - 8 SPATIAL RESOLUTION OF OPTICAL SYSTEMS

This course considers the standard instruments and measurement techniques in Laser/Electro-Optics Technology which are important to the technician. The first three modules treat optical instruments under the general names of spectrometers, monochromators, and spectrophotometers. The modules explain their use in making spectral measurements of light sources to determine both wavelength and intensity distribution of the light. The next set of modules discusses the various types of interferometers available to the technician and their many uses in making interferometric measurements on small thicknesses, surface irregularities, wavelength determination and the like. The last module in this course considers an important problem in modern optics which involves the spatial resolution of optical systems.

The emphasis in this course is on measurements with optical instruments. The theory and principles which underlie the operation of these instruments, presented in detail in Course 5 are referred to again in each module to strengthen the students understanding of wave optics. Nevertheless, it is the intent of Course 10 to enable the student to obtain laboratory experience in Laser/Electro-Optic Measurements with modern optical equipment.

Price: per course \$20.00

per module \$ 3.00

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LASER/ELECTRO-OPTIC TECHNOLOGY (LEOT) MODULES

ORDER FORM

PLEASE SEND ME THE FOLLOWING LEOT MODULES:

COURSE NO. _____ (____ MODULES @\$ 2.50)

COURSE NO. _____ (____ MODULES @\$ 2.50)

SEPARATE MODULES NO. _____

_____ (____ MODULES @\$ 3.00)

SUPPLEMENTARY MODULES:

LABORATORY NOTEBOOK _____

MEASUREMENTS & ERRORS _____

☐ ENCLOSED CHECK ☐ BILL ME

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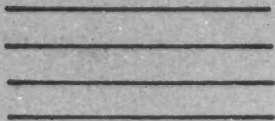
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COMPANY

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PLACE
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HERE

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TECHNICAL EDUCATION RESEARCH CENTER-SW
4201 LAKESHORE DRIVE, SUITE III
WACO, TEXAS 76710

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for more information

Technical Education Research Centers (TERC) is a private, non-profit organization dedicated to research, development and dissemination of technical educational programs in the United States. The materials described in this brochure, as well as the following list of materials related to the Laser/Electro-Optics Technology are available from TERC at the address below.

1. Curriculum Guide.
2. Tips for Teachers of Course I.
3. LEOT Educational Equipment and Supplies.
4. Career Opportunities in Lasers.



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laser electro-optics technology





an exciting new career

The laser is no longer a scientific curiosity looking for an application. Lasers are being used in industry with applications in automatic supermarket check-outs, communications, surveying, construction alignment, welding, and product testing. It is a tool so delicate it can pierce a diamond; and so precise that a millionth of an inch can be measured with ease.

Laser/Electro-Optics Technology is rapidly developing with essentially unlimited potential for the trained technician. This field is challenging at many levels of technical expertise and provides jobs with great personal satisfaction and potential for rapid advancement.

Laser/Electro-Optics (LEO) technicians are needed to develop, assemble, operate, test and maintain lasers and other optical devices for use in industry.

an education program

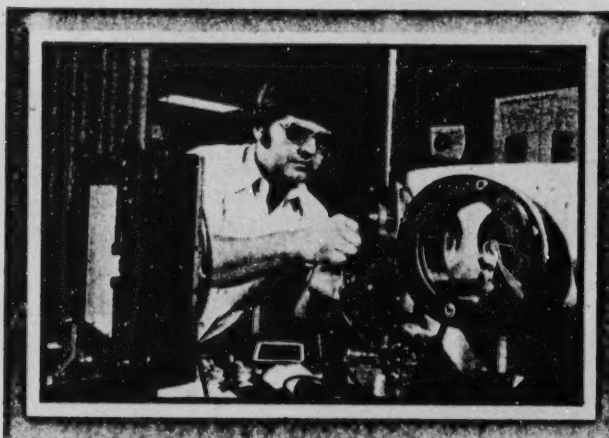
An educational program for LEO technicians has been developed under the sponsorship of the United States Office of Education. The curriculum is designed to be used by two-year, post secondary schools to prepare students for entry level employment or advance training of technicians who are already employed in the related fields. The instructional materials are also being used by employees for "in-house" training and by individuals for self-study.

The LEO Program is a complete and comprehensive educational plan for learning LEO Technology. The program was written by people actively employed in various aspects of the LEO industry. The curriculum was guided by an Industrial Advisory Committee consisting of representatives that actually hire LEO technicians. To insure the program is educationally sound, the program was designed by educational specialists. Each of the one hundred instructional modules contains measurable performance based objectives with "hands-on" laboratory experiments. The materials have been used successfully in the following ways:

1. Two-year programs for preparing new LEO technicians.
2. Supplements to existing programs in physics, electronics, glass-working, vacuum systems, etc.
3. Short courses for presenting specific information to existing employees.
4. Industrial "in-house" instruction.

Because of the modular approach, the program is flexible enough to be adapted to local employment needs.

This is a proven program which has been evaluated in a model two-year program at Texas State Technical Institute. Over 75 graduates during the past four years have used the materials and are now successfully employed in the LEO industry.



contents of text materials

COURSE I - INTRODUCTION TO LASERS (Eleven modules) - to introduce the new student to the principles of a laser, its output characteristics and safe operating practices.

COURSE II - GEOMETRIC OPTICS (Eleven modules) - to give the student the mathematical ability and graphical techniques necessary to analyze a ray of light as it passes through an optical component system.

COURSE III - LASER TECHNOLOGY (Eleven modules) - to explore in depth six specialized groupings of lasers.

COURSE IV - EXPERIMENTAL OPTICAL METHODS (Nine modules) - to develop the skills and knowledge necessary to produce usable items



from a laboratory glassworking shop and laboratory vacuum system necessary in LEO technology.

COURSE V - LIGHT SOURCES AND WAVE OPTICS (Eleven modules) - to give a thorough understanding of the characteristics of light sources and the wave nature of light and holography.

COURSE VI - LASER AND ELECTRO-OPTIC COMPONENTS (Eleven modules) - to give the student the practical understanding of optical components and accessories ordinarily derived only from years of experience in the laboratory.

COURSE VII - LASER ELECTRO-OPTIC DEVICES (Ten modules) - to explain the theory and operation of special purpose devices to measure laser output parameters, modulate and Q-switch lasers; also includes special techniques in photography and holography.

COURSE VIII - LASER APPLICATION (Ten modules) - a study of the current application of lasers in material processing, data processing, testing and monitoring, ranging and alignment, communication, and medicine.

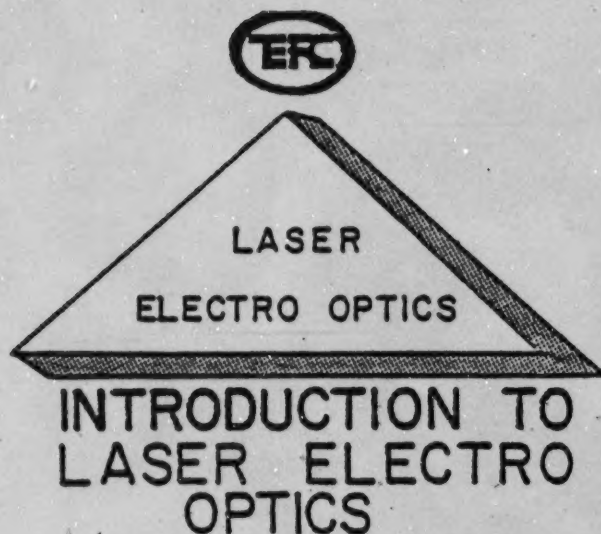
COURSE IX - LASER PROJECTS (Seven modules) - the student will build and operate a laser or electro-optical device to acquire actual job experience in building, operating, and testing a LEO system.

COURSE X - LASER/ELECTRO-OPTIC MEASUREMENTS (Eight modules) - to study spectrometers, interferometers and associated measurement techniques which are important in LEO technology.

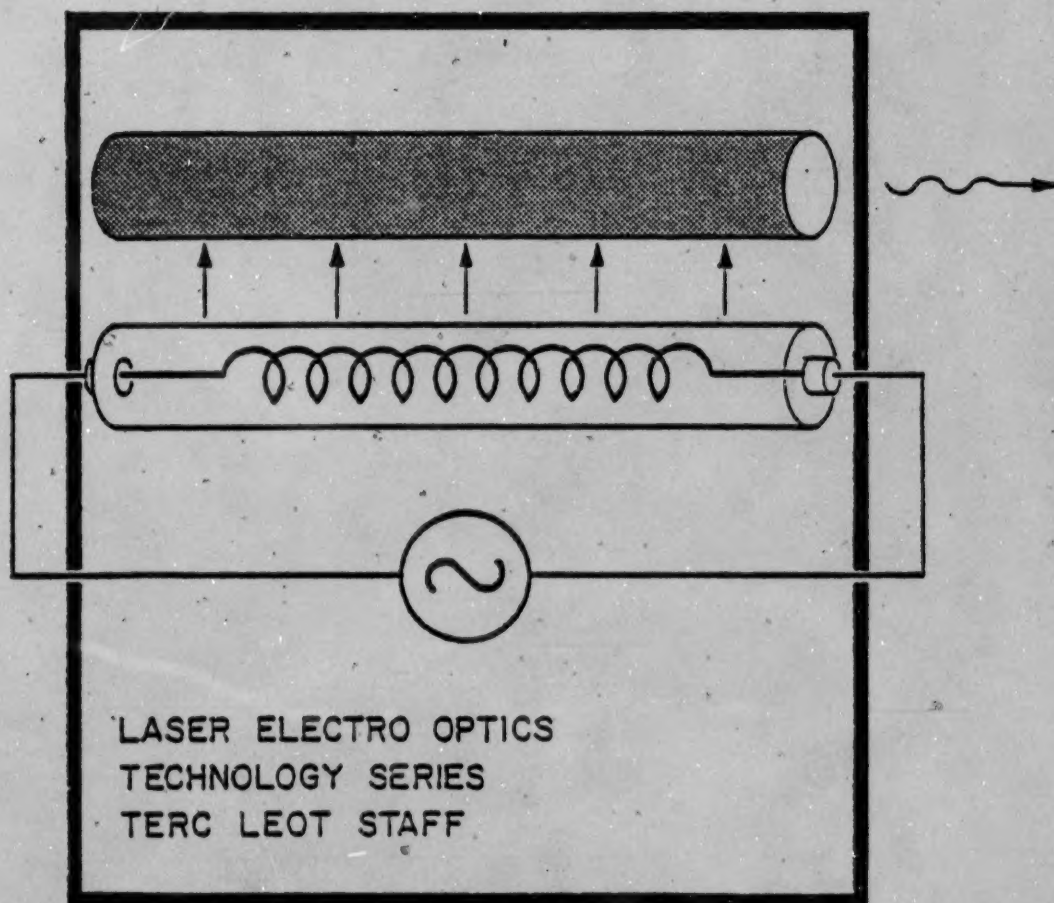
APPENDIX C

Sample Module from the LEOT Curriculum

APPENDIX C
SAMPLE MODULE



Module 1-10. Helium-Neon Gas Laser - A Case Study





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Gas lasers can be grouped into three basic types or classes: neutral atom, ion and molecular.

I. "Neutral atom" indicates that the atoms comprising the active medium are electrically neutral or balanced, i.e., they have equal numbers of positively charged protons and negatively charged electrons (example: helium-neon, He-Ne).

II. An ion is an atom having one or more electrons missing from one of its electronic shells; hence it has a net positive charge. An ion gas laser has as an active medium a collection of such ions (example: singly ionized argon, A^+).

III. A molecule is composed of two or more atoms either of the same or of different atomic species. A molecular gas laser employs a large number of such molecules as a lasing material (example: carbon dioxide, CO_2).

The importance of He-Ne gas lasers for a growing number of commercial applications is well established. For example, He-Ne laser systems are being used in surveying, pipeline laying, position sensing for earth moving operations, vibration monitoring and materials testing.

The purpose of this module is to examine each of the four elements of the He-Ne laser in greater depth, as well as some of the hardware associated with He-Ne laser systems. Characteristics of power supplies and plasma tubes for off-the-

shelf He-Ne lasers will be discussed. Procedures for cleaning optical components, such as laser mirrors and Brewster windows, and for alignment of mirrors will be given.

MODULE PREREQUISITES

Knowledge of basic algebra, laser safety precautions, and operating procedures for a helium-neon laser and an optical power meter are required.

OBJECTIVES

- ° Draw and label an energy level diagram for a He-Ne laser.

The completed diagram must include the pairs of energy levels between which lasing transitions occur, the three lasing wavelengths, metastable levels, resonant excitation of neon atoms and pumping of helium atoms from the ground state to metastable states by electron collisions.

- ° Demonstrate knowledge of Helium-Neon laser components and operation by writing statements of definitions, comparison, reasons and details to all of the following problems. Ideas communicated must convey the same meanings as described in the text.
 - a) Define buffer gas in a He-Ne laser and state its purpose.
 - b) Describe the process of resonant excitation.
 - c) Describe the phenomenon of super radiant lasing.

- d) Describe the magnetic field method for suppressing oscillations at the He-Ne infrared lasing wavelengths and state why such suppression is necessary.
 - e) State the purpose of the gas reservoir, capillary tube and the getter in a plasma tube.
 - f) Describe why cold cathode plasma tubes are preferred over hot cathode types.
- Calculate the total gas fill pressure and partial pressures of helium and neon for optimum power output.

The plasma tube bore will be given. The student must use the equation $P = \frac{0.40}{d}$ and the pressure must be in the units of torr. The answer must be correct to two significant figures and the ratio of partial pressures of helium to neon be $\approx \frac{9}{1}$.

- On a block diagram for a typical power supply used to excite a He-Ne plasma tube, label each element, and on a separate sheet of paper state its purpose.

The diagram will be given and the student must properly label all of the following items:

input line voltage
step up transformer
high voltage exciter current
rectifier/voltage multiplier
ballast resistance

The purpose of each element must convey the same meaning as stated in the discussion.

- Draw curves on a graph of percent transmittance vs. wavelength for typical He-Ne laser high-reflectance and output mirrors.

The axes for the graph will be given and the critical portions of the curves will be the minima.

- Clean the laser mirrors and Brewster windows for an open-cavity He-Ne laser.

Materials to be used are listed in the materials section of the module and the module cleaning procedure may be used. The mirrors and windows must be inspected by the instructor to determine if they are free of dust particles, smears or streaks or any condition indicating an unclean surface.

- Align the two mirrors of an open cavity He-Ne laser and measure the peak power.

Materials to be used are listed in the materials section of the module and the module's alignment procedures may be used. Alignment to obtain an output beam in the TEM₀₀ mode is required and the peak power must be within $\pm 20\%$ of the peak power recently measured by the instructor.

- ° Using the equipment listed in the materials section of the module and the module procedures, operate the helium neon laser to perform the following tasks:

- a) Plot a voltage-current characteristic curve for a He-Ne plasma tube by varying the input voltage and measuring tube voltage and current. Identify the breakdown voltage region and the region of negative resistance of the curve.

The plotted curve must be such that the region of negative resistance and the breakdown voltage region can be easily identified and resemble the curve presented in the discussion.

- b) Plot a graph of Power Output vs. Tube Current of a He-Ne laser by varying tube current. Identify on the graph the unstable region, the operating range and the saturation region.

The unstable region, operating range and the saturation region must be easily identified and the curve resemble the curve presented in the discussion.

DISCUSSION

The Active Medium

In Module 1-1, the general features of helium-neon lasers were outlined. See Figure 10-1 below. It was mentioned that lasing is observed in neon gas, without the addition of helium. In fact it would be more proper, perhaps, to label He-Ne lasers as Neon lasers since neon gas is the active medium;

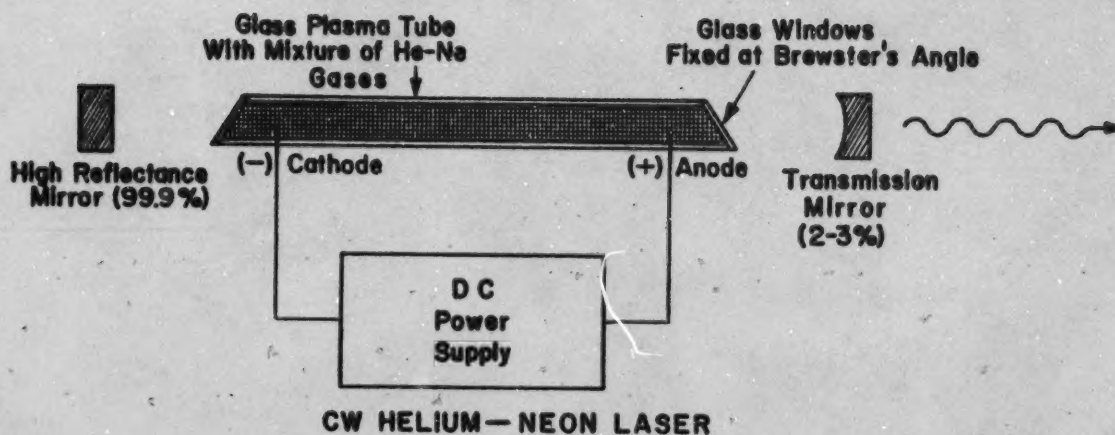


Figure 10-1. CW Helium - Neon Laser

helium acts as a buffer gas. That is, helium enhances lasing by increasing the pumping efficiency. To see how this works, examine Figure 10-2, which is a combined energy level diagram for neon and helium. Only a few of the many energy levels are shown for simplicity. Notice that two levels in neon, E_3 and E_5 , have nearly the same energy as two excited states in helium. This is the key to increased pumping efficiency. Electrons, released at the cathode, are accelerated towards the anode by the voltage applied across the plasma tube. This results in energetic collisions between electrons and gaseous atoms. Helium atoms, however, weigh

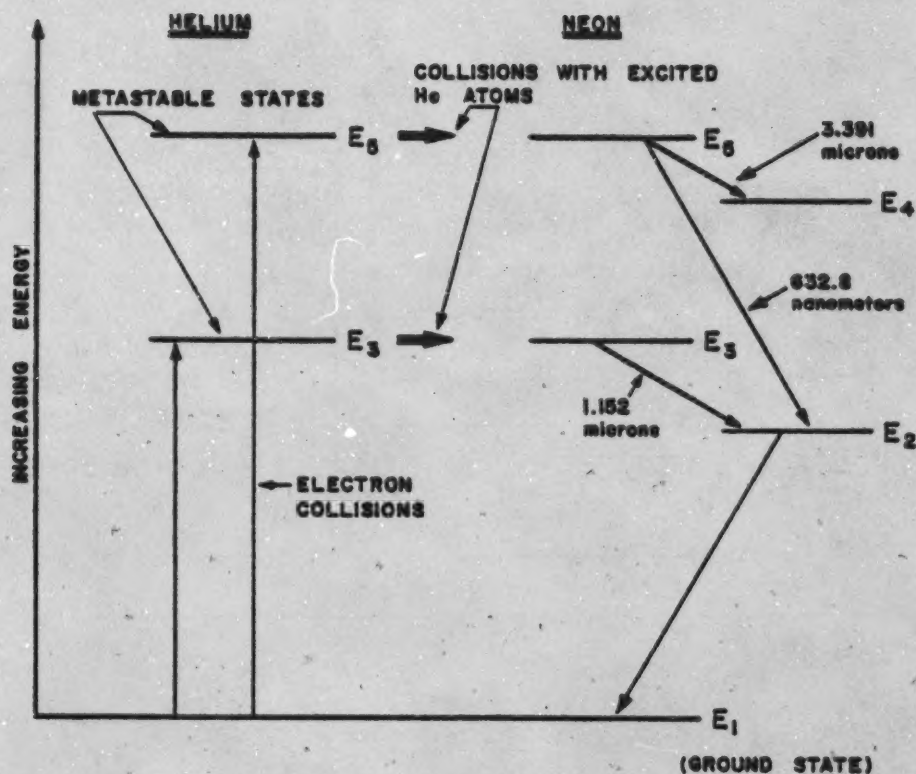


Figure 10-2. Simplified Energy Level Diagram for He-Ne Laser.

only about one-fifth as much as neon atoms. Therefore, it is much easier for electrons to transfer energy to helium atoms via collisions, resulting in excitation to metastable levels E_3 and E_5 . Thereafter, excitation of neon atoms to levels E_3 and E_5 occurs by means of collisions with excited helium atoms. The process of pumping the active laser gas indirectly by transfer of energy via collisions with another excited gas is called resonant excitation, and has been used in several types of gas lasers. For example, although lasing

action has been observed in carbon dioxide (CO_2) alone, the pumping efficiency is greatly improved if a quantity of nitrogen (N_2) is added as a buffer gas.

If resonant transfer of energy from He metastable atoms to Ne atoms occurs at a rate faster than the decay rate from E_5 and E_3 to lower levels, then population inversion may be achieved. Stimulated emission of radiation in neon occurs at a number of wavelengths. Three of the more important lasing lines are shown in Figure 10-2, including the familiar line at 632.8 nm in the red portion of the spectrum, and two additional lines at 1.152 μm and 3.39 μm in the infrared. Notice that the two lines at 3.39 μm and 632.8 nm share the same upper energy level, E_5 , while the 1.15 μm and 632.8 nm lines terminate on the same lower level, E_2 .

It is possible that all three of these wavelengths will be present in the laser output simultaneously. If one is interested in a He-Ne laser whose output is at the 632.8 nm wavelength only, positive steps must be taken to suppress oscillations at, for example, the 3.39 μm wavelength. Both the 3.39 μm and 1.15 μm lines have greater gain than the 632.8 nm lines, and hence are capable of "stealing" power that would otherwise be available as output at the 632.8 nm wavelength. In fact, the gain is so great for the 3.39 μm that it is possible to obtain lasing at this wavelength without a pair of mirrors for feedback. The phenomenon of achieving an output from a laser with high gain without the use of a pair of mirrors is called super-radiant lasing.

How do we control gain to suppress unwanted lasing? Elimination of oscillations at 3.39 μm is sometimes accomplished by placing a number of magnets at various positions outside the plasma tube. What does this do? Briefly, the magnetic field induces a broadening of the 3.39 μm line. However, amplifier gain G_a is strongly dependent on the line-width $\Delta\nu$, as can be seen from the following approximate relationship:

$$G \propto e^{-(\Delta\nu)^2} \quad (10-1)$$

From eqn. (10-1) we can see that the larger the width of the spectral line ($\Delta\nu$), the smaller will be the resulting gain. Thus it is possible by proper application of a magnetic field to reduce gain in the 3.39 μm line to a negligible value. However, the bandwidth of the 632.8 nm is only slightly affected by the magnetic field. This means that output power may be increased some 15 - 20% at 632.8 nm by suppression of the 3.39 μm line. Other methods of suppression include intra-cavity tuning with a prism or placement of an absorber at 3.39 μm such as methane gas in the cavity. Consult reference 3 for a more complete discussion of infrared line suppression.

An examination of most commercial He-Ne lasers will reveal that no active steps have been used to eliminate the infrared lines, other than use of selective mirror coatings with reflective bandpass strongly peaked at 632.8 nm. One factor

not mentioned thus far is the dependence of gain on the length of the plasma tube. In Module 1-7 we saw that the small signal amplifier gain was dependent on the active length of the active medium, x : where x is the gain coefficient. Consequently,

$$Ga = e^{\alpha x} \quad (10-2)$$

for plasma tubes of moderate length, say 10 - 40 cm, allowing stimulated emission at 3.39 μm and/or 1.15 μm will not seriously degrade the output power at 632.8 nm. For longer tubes, however, it becomes an important consideration. In this case He-Ne laser manufacturers often use the magnetic field method of suppressing the infrared lines.

Commercial He-Ne Plasma Tubes

In this section we will point out several features of He-Ne plasma tubes used in laboratory and industrial applications. Refer to Figure 10-3, which displays an example of the internal-mirror type of He-Ne plasma tube.

Lasing occurs in the long, thin piece of capillary tubing (I.D. 1-5 mm, approx.), onto the ends of which are epoxied multilayer dielectric coated mirrors to form the optical cavity. Above the capillary and connected to it is a glass envelope of much larger diameter (about 25 - 38 mm), called the gas reservoir, which contains a mixture of helium and neon gases. Helium has a tendency to diffuse through glass walls. Therefore, it is necessary to have a much larger

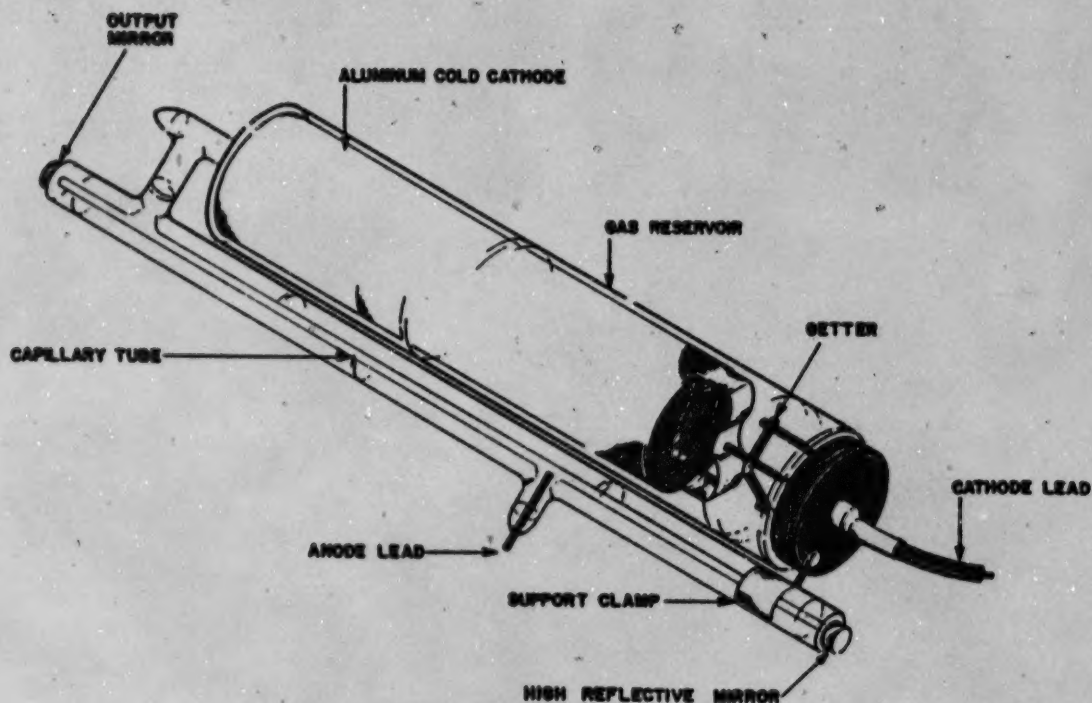


Figure 10-3. Typical Helium-Neon Plasma Tube:
Cold Cathode Type

supply of helium than is required just to fill the capillary tubing. Diffusion of helium is the principal reason why plasma tubes get "low on gas", that is, the pressure becomes too low for laser operation.

For maximum power output the total gas fill pressure P in a He-Ne plasma tube is dependent upon the capillary tube diameter d , according to the empirical equation:

$$P \approx \frac{0.4}{d} \quad (10-3)$$

where P is measured in Torr* and d is expressed in centimeters. For example, for a plasma tube of capillary bore 2.5 mm, the gas fill pressure should be about:

$$P = \frac{0.4}{0.25}$$

$$= 1.60 \text{ Torr}$$

Eqn. 10-3 for the tube pressure P should not be taken as a "magic recipe" but merely as a rule of thumb. Operating He-He lasers have been constructed whose fill pressure is greater than or lower than that prescribed by (10-3) for a given tube bore d. Likewise, various formulas exist for the ratio of helium to neon to be used to insure effective operation. One figure often given for the pressure ratio is:

$$\frac{P_{\text{He}}}{P_{\text{Ne}}} \approx \frac{9}{1} \quad (10-4)$$

which means that $P_{\text{He}} = 0.9 P$ and $P_{\text{Ne}} = 0.1 P$. Thus, for

*Note: Pressure is defined as the force per unit area exerted on an object (Units: newtons/m² or pounds/in²). The pressure exerted on all objects at sea level due to the atmosphere is in approximately 14.7 lbs/in². Pressure may also be expressed in terms of the height of a column of liquid produced by a given pressure. For example, 1 atmosphere (14.7 lbs/in²) of pressure raises a column of mercury to a height of 760 mm at 0°C. The unit of pressure known as the torr (T) is equivalent to a pressure of 1mm of mercury, or 1/760 of an atmosphere.

example, assuming a total gas fill pressure $P = 1.60$ torr, and using eqn. (10-4) the partial pressures of helium (P_{He}) and neon (P_{Ne}) would be:

$$P_{\text{He}} = 1.44 \text{ Torr}$$

and

$$P_{\text{Ne}} = 0.16 \text{ Torr}$$

Various types of cathodes have been used in He-Ne plasma tubes. Figure 10-3 displays the cold-cathode type, to be distinguished from hot cathodes employing a tungsten filament heated to incandescence. The cathode shown is a hollow cylinder made from aluminum alloy. Contaminants in a plasma tube should be kept to a minimum to avoid "poisoning" the gas mixture. One type of contaminant comes from the material from which the cathode is fabricated. It is possible that some atoms in the metal cathode may be physically jarred loose by bombardment from positively charged ions attracted to it, a process known as sputtering. Pure aluminum and certain of its alloys have very low sputtering rates, and hence, make good candidates for cathode materials. Commercial plasma tubes employing cold aluminum cathodes have a useful lifetime of some 10,000 hours or more. Probably the most serious disadvantage of hot cathodes is their relatively short lifetime due to increased amount of sputtering from a heated filament, i.e., it is more susceptible to damage by positive ion bombardment. Another step often taken to reduce con-

taminants in the gas mixture is the use of a getter, also shown in Figure 10-3. This is a small filament attached electrically to the cathode. It has the effect of "soaking up" or trapping impurities present in the gas fill. The anode is a short, thin rod, often made of nickel.

Excitation Mechanism

Now, let's talk about some electrical characteristics of He-Ne plasma tubes and the power supplies used for their excitation. The block diagram for a typical high-voltage, low-current dc power supply found in commercial He-Ne lasers is displayed in Figure 10-4.

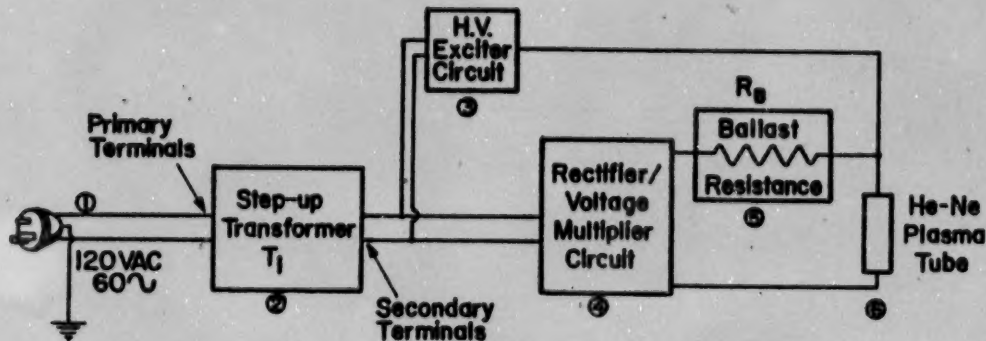


Figure 10-4. Block Diagram of Power Supply

Input voltage (1) from an ac outlet is increased or stepped-up by a device known as a transformer (2). The rectifier circuit (4) converts ac to dc and acts as a voltage

multiplier, for example, doubling the peak input ac voltage produced at the secondary terminals of the transformer. It provides the necessary dc voltage/current for steady-state, continuous wave (CW) operation of the laser plasma tube. The exciter circuit (3) supplies a high-voltage pulse which breaks down the neon gas, i.e., initiates the glow discharge, within the plasma tube. The ballast resistance (5), placed in series with the dc output of the rectifier circuit, limits current through the tube to a safe value. The plasma tube (6) itself acts as a nonlinear resistance in the circuit.

To see why these circuit elements are necessary, note that we are trying to initiate a stable glow discharge inside the plasma tube. To do this, it is necessary to ionize a few of the gaseous atoms within the tube. The word plasma, coined by Langmuir in the 1920's, was originally defined as a weakly ionized gas. Recall that ionization is the process of removing one or more negatively charged electrons from an atom, leaving it positively charged. To remove an electron from the outermost shell of an atom requires a definite amount of energy that must be pumped in, called the ionization potential energy, usually given in electron-volts (eV). The exact value of the ionization energy depends upon the structure of the atom. For example, helium (He) has an ionization energy of 24.6 eV, neon (Ne) of 21.5 eV, and argon of 15.8 eV. Note that the ionization energy of Ne is less than that of He.

Examine Figure 10-5. It displays the voltage-current characteristic curve for a typical low output power (2-3mW),

He-Ne plasma tube. There are three main features to note. First, very little current flows through the tube until the applied voltage across the tube reaches a certain point - the "hump" on the curve. This is called the breakdown voltage. For this particular plasma tube the breakdown voltage is experimentally measured to be about 3400 volts. When the breakdown voltage or potential is applied, some of the atoms are ionized - a neon plasma is created - resulting in a large increase in plasma tube current. Actually, for applied voltages less than the breakdown potential, only a few microamps or even less are flowing through the tube.

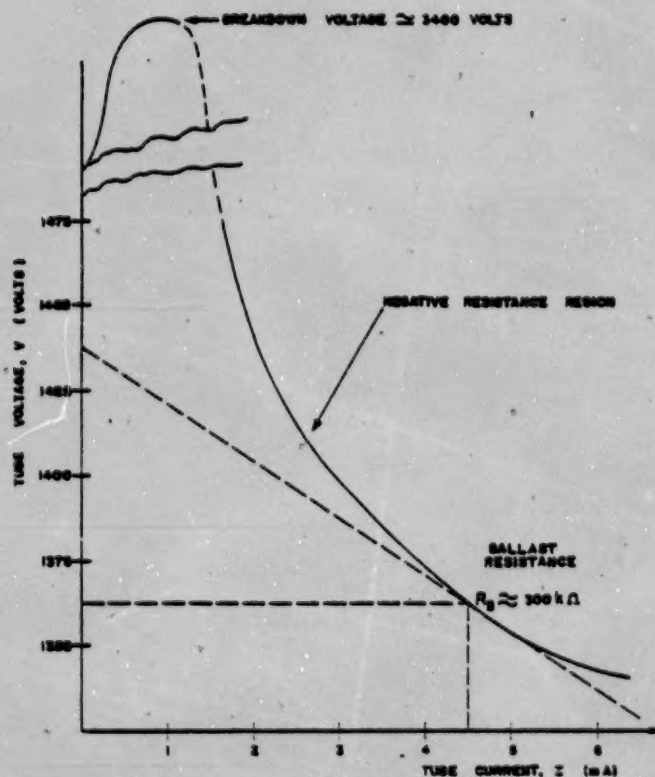


Figure 10-5. Voltage-Current Characteristic Curve for Fe-Ne Plasma Tube (V-I Curve).

It should be mentioned that only a small percentage of the neon atoms inside the tube are ionized (probably less than 0.01%) - it is indeed a "weakly ionized" gas.

The voltage "hump" in Figure 10-5 necessitates some sort of "voltage kicker" circuit to momentarily raise the tube voltage to a high value (several kilovolts) and initiate ionization. This is the purpose of the high-voltage exciter circuit in Figure 10-5. The second feature of the V-I curve is that the greatly expanded lower part of the voltage scale shows that, after breakdown, it takes much less voltage across the tube to maintain a stable glow discharge. The dc voltage, for the operating range of the laser tube, is supplied by the rectifier/voltage multiplier portion of Figure 10-4. For example, suppose transformer T_1 steps up the input voltage by a factor of 7. With an input to T_1 of 120 VAC, the peak voltage produced by the rectifier/voltage multiplier circuit will be about 1680 volts, and that of the exciter circuit will be approximately 3360 volts, assuming that the rectifier circuit doubles and the exciter quadruples the voltage delivered at the secondary terminals of T_1 .

A third characteristic to note in Figure 10-5 is the negative resistance region. What does this mean? Refer to Figure 10-6. Suppose we gradually increase the voltage across the load resistor R_B by adjusting potentiometer R_1 , and measure the resulting change in current through R_B . If the current through R_B increases linearly with increasing applied voltage, then Ohm's Law is said to be obeyed by the resistance R_B .

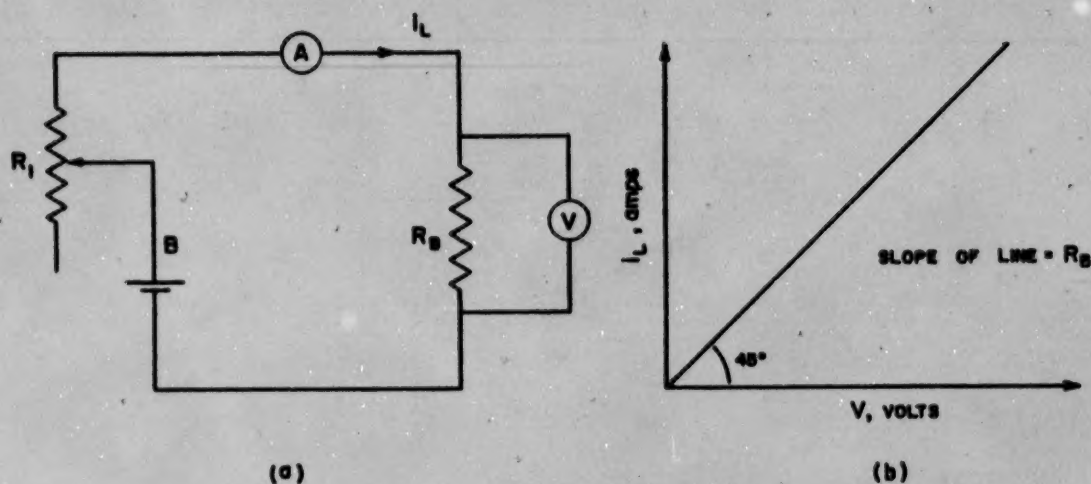


Figure 10-6. Ohm's Law Experiment

R_B is a constant in this case:

$$R_B = \frac{V}{I_L} \quad (10-3)$$

The slope of the curve in Figure (10-6) is positive - the resistance element is said to have positive resistance, $R_B > 0$. The resistance of a copper wire, for example, obeys Ohm's Law quite well. However, some conductors do not conform to Ohm's Law. For example, the resistance of a vacuum diode tube or of a thermistor are by no means constant - the current flowing through either is not a linearly increasing function of applied voltage.

Refer back to Figure 10-4. Consider the plasma tube, connected across the output terminals of the dc power supply, as a resistance element. The V-I curve, Figure 10-5, tells us that a glow-discharge tube does not obey Ohm's Law. Specifically, there is a region of negative resistance, in which a decrease in voltage across the tube results in an increase in tube current. The slope of the curve in this region is negative, which implies that the effective resistance of the plasma tube in this region is also negative. If the increase in tube current were not limited in some way, it might rise to such a large value as to do physical damage to the tube. Hence, in Figure 10-4, a resistance R_B is placed in series with the output of the rectifier/voltage multiplier circuit, effectively restricting current flow to a safe value, while permitting enough current through the tube to obtain a usable amount of output power. The resistor R_B is called a ballast resistance. Its function is similar to the inductor in the start circuit for a fluorescent lamp. Besides providing the "voltage kick" for starting the lamp, the inductor acts as a ballast resistance to limit current flow through the lamp to a safe value. For an operating current of ~ 4.5 mA, the ballast resistance R_B would have to be about 300 k Ω (see Figure 10-5).

An experimental plot of output power as a function of plasma tube current for the same He-Ne laser (V-I characteristic given in Figure 10-5) is provided in the following drawing:

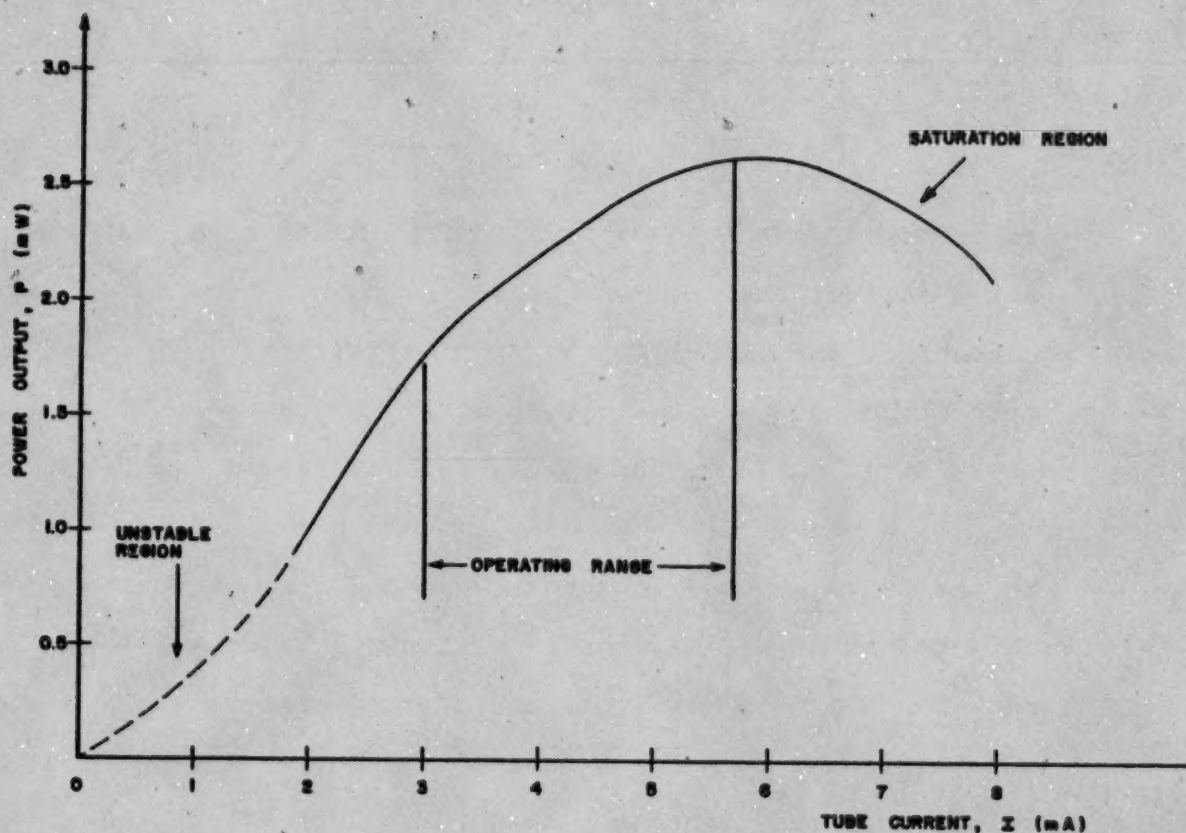


Figure 10-7. Power Output of He-Ne Laser vs. Plasma Tube Current (P-I curve)

Note the three regions shown in the graph. For tube currents less than 2mA, the gas discharge is in the unstable region. Visually, the light emitted by the glowing gas flickers on and off intermittently. Coherent light output would not be seen with the eye. The light emitted by the tube during each brief "burst" is due to (incoherent) spontaneous emission. Likewise zero power output would be detected with an optical power meter. For currents greater than 2 mA, a stable dis-

charge is observed and measurable power outputs can be noted with a power meter. This is the usual operating range for the laser. Usable laser output at 632.8 nm in the power range 1 - 2.6 mW is obtained by varying tube current (hence adjusting ballast resistance R_B or the input voltage to the transformer in the power supply) from about 2 mA - 5.7 mA. For a ballast resistance $R_B \approx 300 \text{ k}\Omega$ recall that the tube current is 4.5 mA. Refer to Figure 10-5. For this tube current, an output power of about 2.3 mW is measured with the power meter. All output powers referred to in this section are for a plasma tube of bore 1 mm and capillary length 30 cm at the 632.8 nm wavelength. Beyond the maximum output power of $\approx 2.6 \text{ mW}$ at 5.7 mA, the P vs. I curve begins to have a negative slope to it, i.e., the power decreases for increasing tube currents. When an increase in tube current will no longer result in further increase in output laser power, the plasma tube is said to be in the saturation region. This phenomenon corresponds to the situation in which more electrical energy is being pumped into the gas than it can actually use for effective excitation. The gas heats up somewhat in this region, and can result in a decrease in plasma tube life. Hence it is desirable to limit current flow in the circuit to values such that saturation is avoided. If current is limited to say, 4.5 mA, saturation is not a problem and a respectable output power of some 2.3 mW would be obtained.

Feedback Mechanism/Output Coupler

Some of the various mirror configurations used in practical lasers were discussed in Module 1-7. In commercial He-Ne gas lasers the hemispherical resonator shown in Figure 10-8 is often employed. It consists of one curved and one flat mirror, separated by a distance L equal to the radius of curvature of the curved mirror. The curved mirror is usually the output or transmission mirror, while the flat has a high-reflectance (HR) coating.

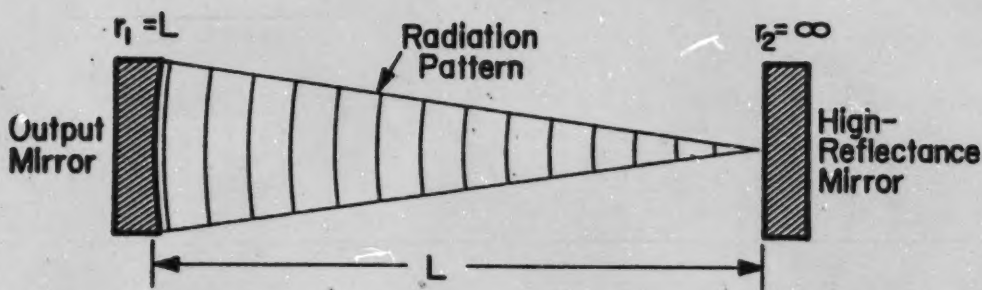


Figure 10-8. Hemispherical Laser Cavity

The multilayer dielectric coatings used are deposited onto a substrate made of fused quartz and are designed to scatter and absorb as little of the laser radiation as possible to help minimize cavity losses. The substrates are ground and polished to a high degree of surface accuracy. Small

imperfections in mirror surfaces are an additional source of output power loss. Curves showing percent transmission as a function of wavelength for typical multilayer dielectric coatings are displayed in Figure 10-9. At $\lambda = 632.8 \text{ nm}$, the reflectance R of the HR mirror is $\geq 99.9\%$, while the transmittance T of the output mirror is $\sim 1.2\%$.

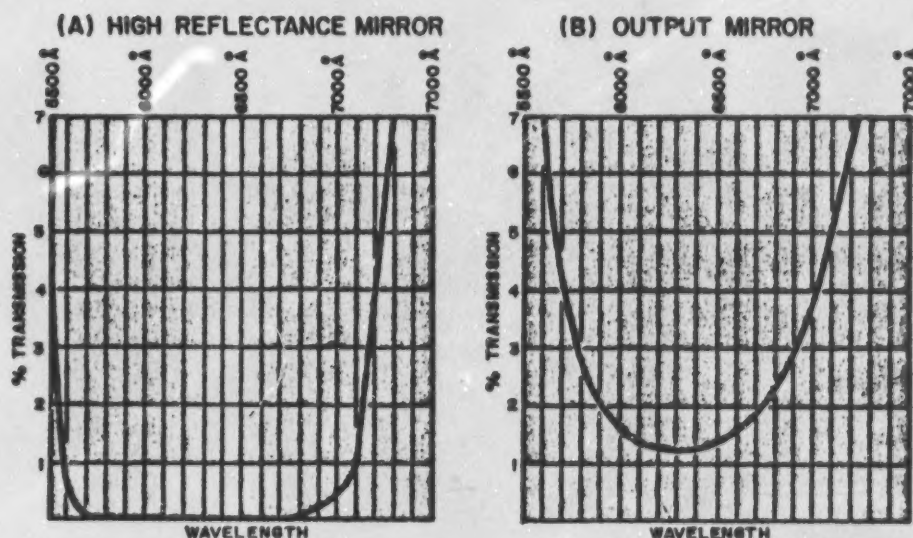


Figure 10-9. Transmission Curves for Typical Multilayer Dielectric Coatings (MLD) Used in He-Ne Mirrors

The mirror separation L in lasers using a hemispherical mirror configuration is usually made a little less than the curved mirror radius r_1 . When $L < r_1$, the wavefront striking the HR mirror hits a larger area than the theoretical diffraction-limited spot area produced in the case $r_1 = L$.

The wavefront, in being reflected from a larger area, is less likely to undergo severe distortions due to optical imperfections in the HR mirror. Such distortions could destroy the self-reproducing radiation field inside the cavity.

One major advantage of the hemispherical cavity is its ease of alignment compared to other configurations, such as the plane-parallel mirror arrangement. As will be seen in a later section in this module, the HR mirror is usually aligned first with respect to the capillary of the plasma tube. This is "the difficult part". Having the curved mirror as an output reflector facilitates the alignment procedure -- there is more tolerance in positioning the curved mirror with respect to the plasma tube axis and the HR mirror.

Cleaning Techniques

It is essential that optical components which are part of the laser or are mounted external to it for beam manipulation be kept clean. Dirty optics within the laser can seriously degrade its output power or even cause physical damage to certain components. The care and cleaning of optics is, therefore, one of the more important job skills of a laser technician. The following comments and procedures are meant as a brief introduction to the subject. A simple scheme for cleaning dielectric coated laser mirrors and Brewster windows will be given. Before attempting to clean optical elements, one should wash his hands thoroughly to remove dirt and oily films. The materials used in the cleaning process are:

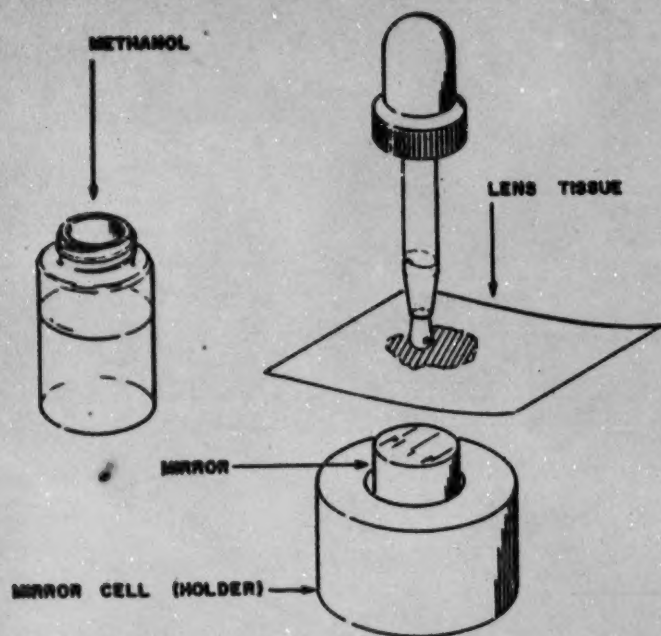
1. Methyl Alcohol (Methanol)
2. Lens tissue
3. Hemostat (surgical pliers)
4. Eyedropper

The steps shown in the drawing (Figure 10-10) should be preceded by a similar cleaning process using a mild detergent such as a commercial lens cleaner or dilute solution of liquid dishwashing detergent, then proceed with cleaning using methanol.

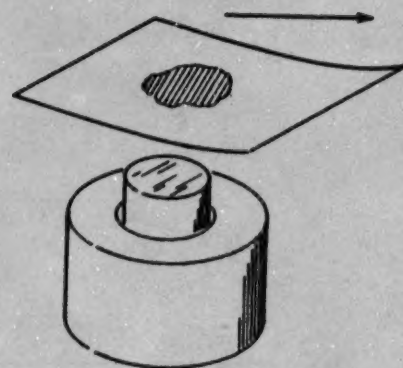
Methanol is a good solvent for effective removal of dust and oils from mirror and glass surfaces. More stubborn films and matter require the use of special detergents, ultrasonic cleaning baths, and other measures. Reference 5 contains a fairly complete discussion of these procedures.

Cavity Alignment

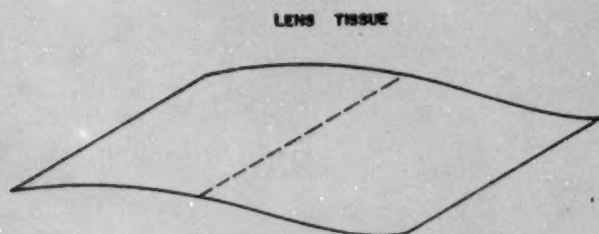
Another important task for the laser technician is the proper adjustment or alignment of mirrors in an open cavity laser to obtain lasing, and ultimately, maximum or peak output power. Imagine a line drawn perpendicular to the center of each laser mirror. When these lines coincide with each other and with the axis of the plasma tube, the optical cavity is said to be aligned. This is illustrated in Figure 10-11. The misalignment shown in Figure 10-11a is deliberately exaggerated.



- (a) Mirror Cleaning, Step 1:
Holding lens tissue above mirror, using eyedropper release 1 or 2 drops of methanol onto tissue.



- (b) Mirror Cleaning, Step 2:
Lower moistened tissue onto mirrors and quickly slide across surface. Use single stroke only. Using fresh piece of lens tissue each time; repeat if necessary until all dust, and streaking are removed.



PAD ABOUT 1" SQUARE

BREWSTER WINDOW

HEMOSTAT

- (c) Brewster Window Cleaning, Step 1:
Fold lens tissue in half lengthwise 5 times and clamp in hemostate. Place 3 drops of methanol on lens tissue.



- (d) Brewster Window Cleaning, Step 2:
Carefully pull moistened pad across window - Do not exert heavy pressure. Repeat if necessary with fresh pad.

Figure 10-10. Cleaning Procedures

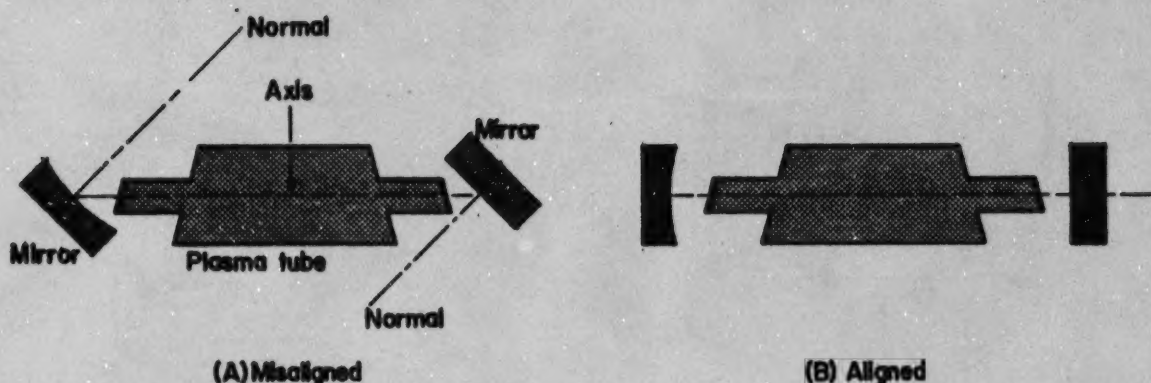


Figure 10-11. Alignment of Optical Cavity

A number of different cavity alignment procedures have been developed. The one given below requires a He-Ne laser and some index cards:

1. Dim the room lights.
2. Mount the plasma tube on an optical bench using adjustable supports. Connect the electrical leads from the power supply to the anode and cathode.
3. Refer to Figure 10-12a. Using a small table with 3-point height adjustment screws, direct a He-Ne laser beam down the center of the plasma tube capillary, observing the transmitted beam on a black card. This is the most difficult part, as it requires adjustment of both the plasma tube and the alignment laser. When the beam is passing through the capillary tube without hitting its side walls or ends, a pattern

of concentric circles about a central bright spot is seen on the card (see Figure 10-12b).

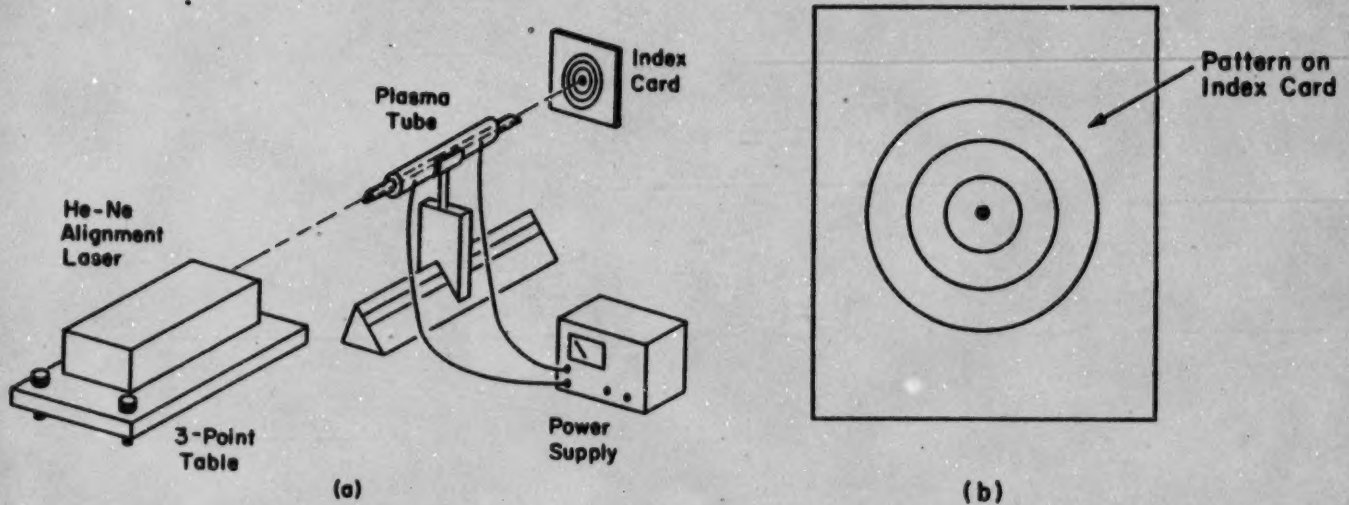


Figure 10-12. Initial Setup for Alignment

4. Refer to Figure 10-12c. Place the high-reflectance (HR) mirror in its mount on the optical bench to the right of the plasma tube. Take an index card and find the beam reflected off of the HR mirror (return beam). Using the X-Y positioning screws on the mirror mounts, superimpose the incident and reflected beams. Some rings of light should be seen on the front of the alignment laser. Slight adjustments of the X-Y positioners should be made to minimize the size of the rings.

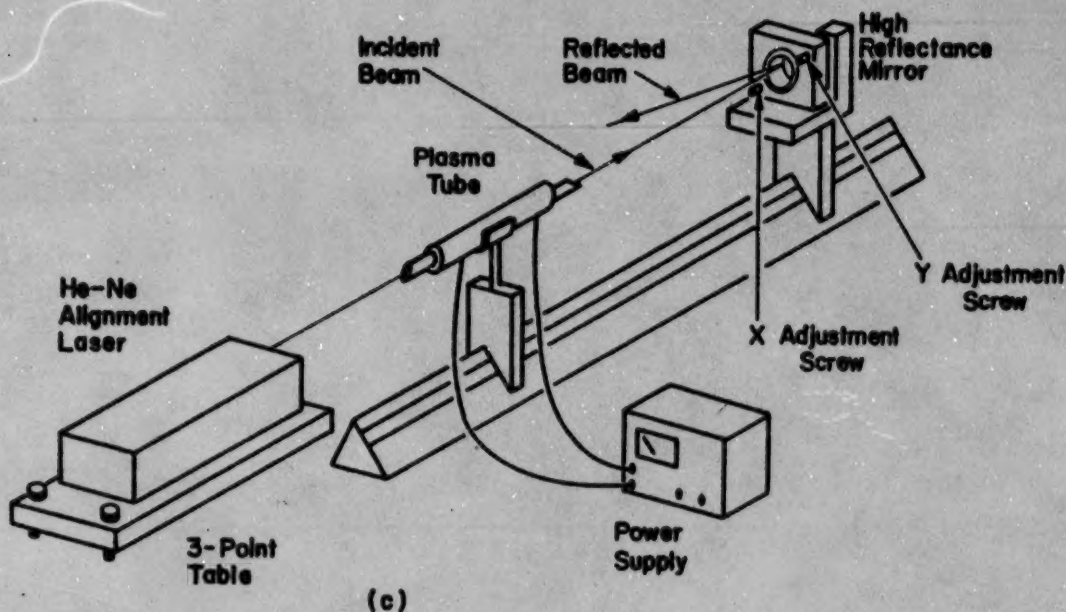


Figure 10-12 (c). HR Mirror: Initial Alignment

5. Consult Figure 10-12d. Take an index card and locate the reflections of the alignment laser beam off of the Brewster window farthest away from the HR mirror. Two bright spots should be seen, along with two relatively faint rings of light. The two spots correspond to the reflections the beam undergoes at the first and second surfaces of the Brewster window on its first pass down the plasma tube. If the HR mirror is not perfectly aligned with respect to the capillary tube axis, the beam reflected by the HR mirror will cause secondary reflections which appear as rings at the Brewster window surfaces on

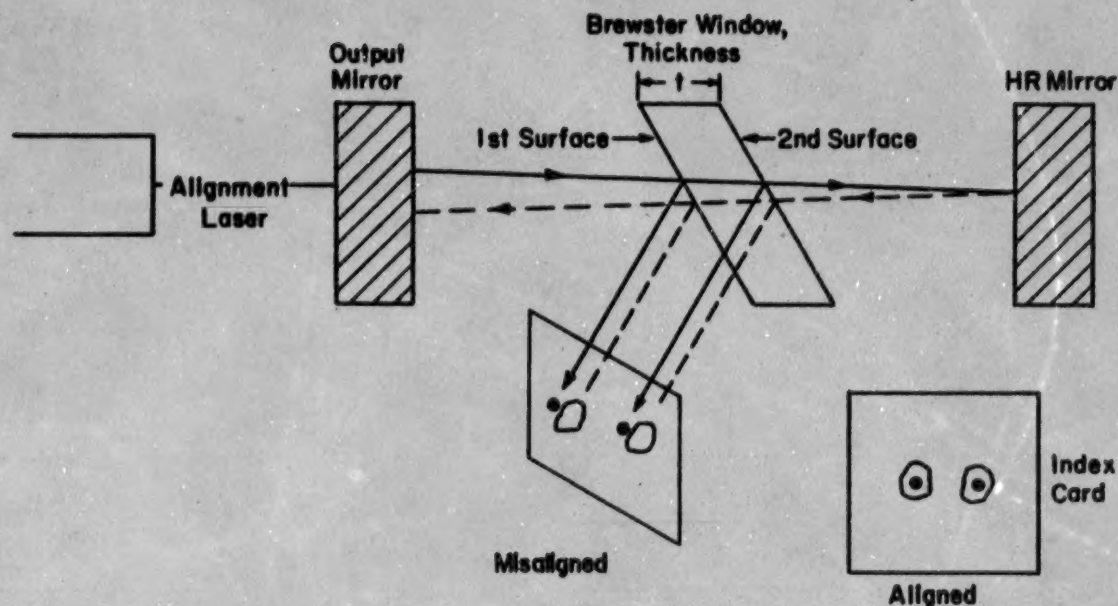


Figure 10-12 (d). HR Mirror: Final Alignment

its pass back through the plasma tube. To achieve better alignment of the HR mirror, adjust the X-Y positioning screws until the spots and rings are superimposed, as shown in the drawing. If alignment of the HR mirror is perfect, the rings will flicker or dim out due to interference effects.

6. See Figure 10-12e. Place the output mirror in its mount to the left of the plasma tube on the bench. Turn on the power supply connected to the tube. Turn both the horizontal and vertical adjustment knobs clockwise until they are screwed in all the way.

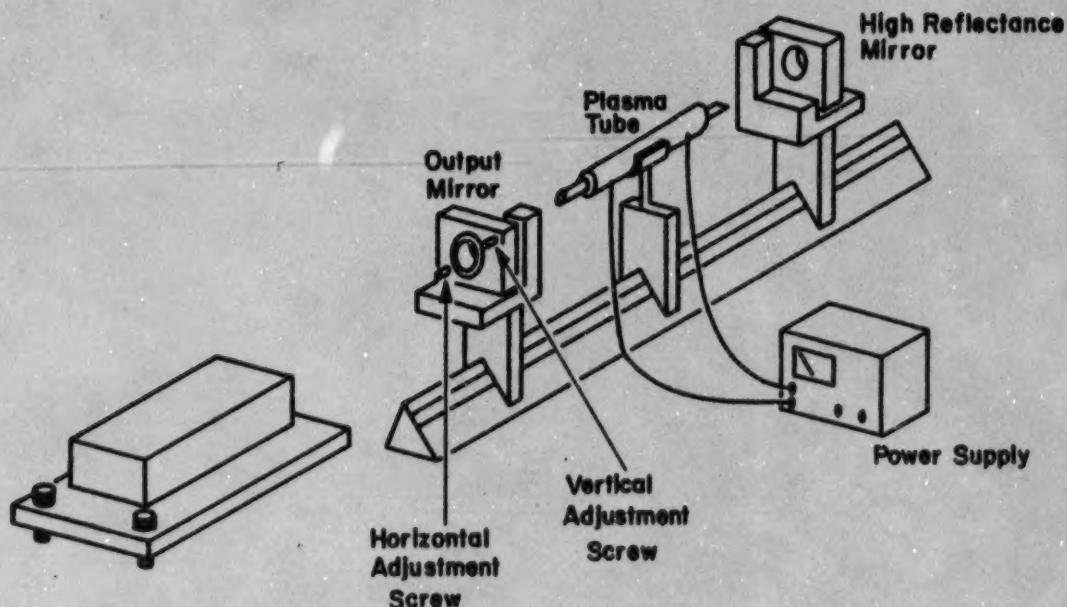


Figure 10-12 (e). Aligning Output Mirror

7. Slowly turn the horizontal adjustment counter clockwise in $1/4$ turn intervals, rocking the mirror mount after each turn. Use your hand to gently rock the top of the mirror mount against its spring tension.
8. Continue the process of turning the horizontal adjustment and rocking the mirror until the laser flickers on briefly. After the laser flickers off and on each time the mirror is rocked, do not turn the horizontal adjustment any further.

9. If no flicker can be obtained after the horizontal adjustment has been rotated well past the midpoint, steps 7 and 8 should be repeated.
10. To achieve a steady light output, slowly rotate the vertical adjustment screw counterclockwise. The laser beam should appear after patient manipulation.
11. Turn off the alignment laser. Place an optical power meter to the left of the output mirror. Adjust the X-Y positioning screws carefully to peak the output power of the laser, as noted on the power meter.

- 1 He-Ne laser (internal mirror type)
- 1 He-Ne plasma tube, w. Brewster window ends
- 2 Mirror mounts, w. X-Y adjustment screws
- 1 High-reflectance mirror ($> 99.9\%$ reflectivity @ 632.8 nm)
- 1 Output mirror (1-2% transmissivity @ 632.8 nm)
- 1 Optical bench
- 2 Pin carriers
- 1 Support rod for plasma tube
- 2 Support bases for mirror mounts
- 1 Optical power meter
- 2 VOM
- 1 Bottle methanol, w. eyedropper
- 1 Pkg. lens tissue
- 1 Hemostat
- 1 Bottle lens cleaner
- 1 Power supply for He-Ne laser
- 1 Autotransformer
- 1 Clip lead

CLEANING AND ALIGNMENT

1. To perform the mirror cleaning, first remove the mirrors from their mounts. Using the step-by-step procedure given in Figure 10-10, clean both laser mirrors and the Brewster windows on the open-cavity He-Ne laser. Ask the instructor to inspect your work.
2. Replace the mirrors in their mounts.
3. Mount the plasma tube on the optical bench with a support rod. Connect the power supply leads to the anode and cathode terminals on the plasma tube.
4. Turn the power supply on. Check to see if the plasma tube "fires", and then turn the power off temporarily.
5. Using the step-by-step procedure given in the text, align the cavity and obtain an output beam in the TEM₀₀ mode.
6. The student is reminded that intra-beam viewing of the alignment laser or its specular reflections should be avoided.
7. Use the adjustment screws on the mirror mounts to peak the output power. Measure the peak beam power with an optical power meter and record the value obtained.
8. List any difficulties found in carrying out both cleaning and alignment procedures.

V-I and P-I CURVES

1. Turn off the laser for a moment and unplug the power supply. Attach one VOM across the cathode and anode terminals on the plasma tube. Set the voltage scale on the VOM to +5,000.

DANGER - HIGH VOLTAGE - BEWARE OF CONTACT WITH PLASMA TUBE LEADS!

2. Connect a second VOM in series with the anode on the plasma tube. Set current scale on VOM to 0-100 mA range. Place an optical power meter in front of the transmission mirror to monitor laser output power.
3. Connect the power cord of the laser power supply to an autotransformer which has been plugged into an ac outlet. Turn on the power supply and slowly turn the knob on the autotransformer in a clockwise direction, increasing the input voltage, until the plasma tube "fires". Observe the reading on the VOM being used for tube voltage monitoring, and measure the breakdown voltage V_{BD} .
4. Repeat step 3 twice and record the average of the three readings for V_{BD} .
5. Turn the knob on the autotransformer back to a zero voltage reading. Again slowly advance the knob clockwise until the tube fires. Some instability in the discharge will probably be noted at this point. Continue increasing the input voltage until a stable glow discharge is observed. Measure and record the plasma tube voltage V , current I and laser output power P at the input voltage where a stable discharge is first observed (refer to Table I).

6. Continue increasing the input voltage via the auto-transformer to vary the output of the power supply delivered to the plasma tube load. Measure and record V, I and P for each 5 volt increment of input voltage up to a maximum of 120 VAC. Record this data in Table I.
7. With the data obtained in steps 5 and 6, plot a voltage-current characteristic curve and a curve of laser output power vs. tube current for the plasma tube used. On the V-I curve, identify the breakdown voltage and region of negative resistance. On the P-I curve, identify the unstable region, operating range and, if possible, the saturation region.
8. Turn the voltage to zero on the autotransformer. Unplug it from the outlet and disconnect the power supply.
9. Attach an insulated clip lead across the plasma tube electrodes to discharge any capacitors in the power supply which may still be partially charged. Disconnect the anode and cathode leads from the power supply.
10. Record:
 - a) the plasma tube manufacturer, serial and/or model number;
 - b) the value of the ballast resistance R_B used in the power supply (see laser manufacturer's spec sheets or the instructor);
 - c) the optical power meter manufacturer and model number.

S	U
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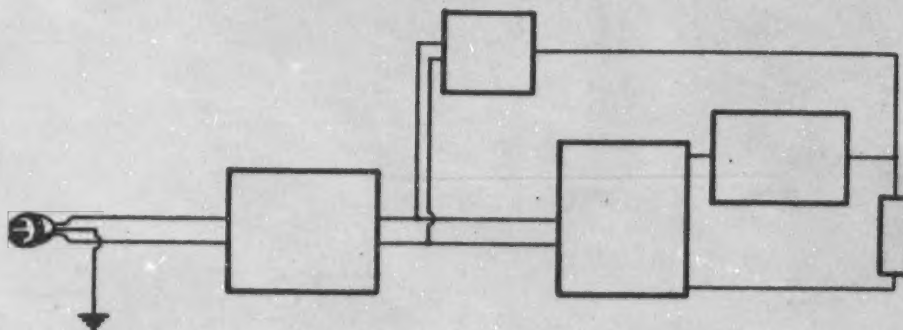
OPTICAL POWER METER
MANUFAC. & MODEL NO. _____

TABLE I.

[illegible]

1. Draw and label an energy level diagram for a He-Ne laser.
2.
 - a) Describe the magnetic field method for suppressing oscillations at the He-Ne infrared lasing wavelengths.
 - b) Why is such suppression sometimes necessary?
3. Define the following terms:
 - a) super-radiant lasing
 - b) resonant excitation
 - c) buffer gas
4.
 - a) State one major advantage which cold cathode plasma tubes have compared with hot cathode types.
 - b) State the purpose of the gas reservoir capillary tube and getter in a plasma tube.
 - c) State a typical figure for the ratio of He to Ne in a He-Ne plasma tube.
5.
 - a) Define the unit of pressure known as the torr.
 - b) State an empirical equation for the optimum total gas fill pressure in terms of the plasma tube bore.
 - c) The capillary of a certain He-Ne plasma tube has a bore of 1 mm. Calculate the optimum total gas fill pressure and the partial pressures of helium and neon gases (see Problem 4c.)

6. a) Label the block diagram for a typical power supply used to excite a He-Ne plasma tube.
- b) State the purpose of the transformer, exciter, rectifier and ballast resistance.



7. Draw a voltage-current characteristic curve for a typical He-Ne plasma tube. Indicate on your drawing and define the breakdown voltage and the region of negative resistance.
8. Draw a power vs. current curve for a He-Ne plasma tube. Indicate on your drawing and define the region of instability, operating range and the saturation region.
9. State one major advantage the hemispherical mirror configuration has in comparison to a plane-parallel resonator.
10. Draw and label graphs of percent transmittance vs. wavelength for a typical high-reflectance and output mirrors, respectively, used in a He-Ne laser.

REFERENCE MATERIALS

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2. Arnold L. Bloom, "Gas Lasers", Applied Optics 5, 1500 (1966)
3. Arnold L. Bloom, Gas Lasers (John Wiley, 1968)
4. Marce Eleccion, "The Family of Lasers: A Survey", IEEE Spectrum, March, 1972.
5. Kodak Irtran Infrared Optical Materials, Kodak Publication No. U-72 (Eastman Kodak, Rochester, 1971).
6. Bela A. Lengyel, Lasers, 2nd edition (Wiley-Interscience, 1971)
7. F. Llewellyn-Jones, The Glow Discharge (London: Methuen & Co., Ltd., 1966)
8. D. Malacara, L. R. Berriel and I. Rizo, "Construction of He-Ne Lasers Operating at 6328 Å", Am. J. Phys. 37, 276 (1969)
9. Arnold R. Shulman, Optical Data Processing (John Wiley, 1970), Appendix 3
10. Douglas C. Sinclair and W. Earl Bell, Gas Laser Technology (Holt, Rinehart and Winston, Inc., 1969)

APPENDIX D

Mail-Out Materials from LEOT Curriculum

TERC Technical
Education
Research
Centers

2901 Bellmead Drive, Waco, Texas 76705 Telephone 817-799-3611
ext. 491

TO: Deans of Instruction
FROM: Dan M. Hull, Project Manager
DATE: September 21, 1973

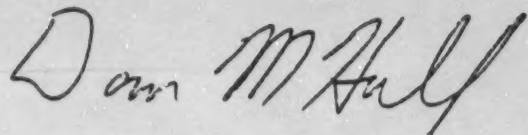
The staff of Technical Education Research Centers, Inc. (Southwest Center) has developed more than 100 instructional modules to support a number of existing quality programs. These "hands on" modules are primarily designed for a post-secondary program in Laser Electro-Optical Technology (LEOT); however they are also suitable for use in the areas of electronics and physics. Student prerequisites include a working knowledge of algebra and trigonometry plus some knowledge of electricity and high school physics.

These instructional modules have been developed under a grant from the U. S. Office of Education. The modules have been student tested and reviewed by a number of industrial specialists, many of whom employ Laser Electro-Optical Technicians. Each module includes measurable objectives and a "laboratory exercise" supportive to those objectives. The modular format for this instructional material was adopted in order to enhance flexibility both in applications and in teaching sequence. In addition, planning materials are available which include curriculum, equipment and facilities information.

The LEOT program at Texas State Technical Institute has been the pilot program for the development, implementation and evaluation of these instructional modules. This program has been an outstanding success. Enrollment in the Laser Electro-Optics Technology Department at Texas State Technical Institute has grown from 4 to over 100 students in less than three years. Graduating students receive several unsolicited job offers each, with excellent starting salaries. These job offers are not only from the laser industry but from the electronic and optic industry as well. The use of the "instructional module" has been an important factor in the success of the TSTI program.

Part of our job at the Technical Education Research Centers is to disseminate these new instructional materials to interested schools throughout the United States. Consistent with this responsibility, a reply form is attached so that you may indicate your areas of interest. It would be helpful if you or a member of your staff returned the attached by October 26, 1973 so that we can plan to serve you in the most effective manner.

DMH:njd



D-1

REPLY FORM

The instructional modules were developed under a grant from the U. S. Office of Education and are suitable for use in the areas of laser electro-optics, electronics and physics. Please respond by October 26, 1973.

Name of Institution _____

Address _____

Telephone Number () _____ Ext. _____

Person preparing this form:

Name _____ Title _____

1. Does your institution provide technical instruction as preparation for job requirements in:

A. Lasers	YES _____	NO _____
B. Electro-Optics	YES _____	NO _____
C. Optics	YES _____	NO _____

2. Do your plans for the future include offerings in the Laser Electro-Optics field:

A. Full two-year curriculum	YES _____	NO _____
B. Options in your existing curricula	YES _____	NO _____
C. Physics courses	YES _____	NO _____
D. Other (Specify) _____		

3. Check the areas in which you are interested:

_____ A. Sample instructional module (from course number* _____)

_____ B. LEOT Curriculum and Equipment material.

_____ C. Potential Employer Information.

4. Person to be contacted at your school for coordination purposes:

Name _____ Title _____

*See Attachment A for course titles. (Attachment A: "Laser Electro/Optics Technology" pamphlet enclosed in Appendix B.)

WE NEED YOUR REPLY
TO OUR LEOT QUESTIONNAIRE

TO: Deans of Instruction
FROM: Dan M. Hull, Project Manager, TERC
DATE: November 16, 1973

We have not heard from you in response to the Laser/Electro-Optic Technology Program Survey (mailed Sept. 21). Please complete the attached form and return it to us as soon as possible.

We need your input - positive or negative - to determine the extent of the national interest in the rapidly expanding fields of optics, electro-optics and lasers.

APPENDIX E

**Major Activities of the Dissemination Project
(exerpted from a monograph by Allen Parker,
and edited for special application).**

APPENDIX E

MAJOR ACTIVITIES OF THE DISSEMINATION PROJECT (exerpted from a monograph by Allen Parker, and edited for special application).

REGIONAL EDUCATOR-EMPLOYER MEETINGS

1. Identify employers and educators for joint meetings.

The disseminator relied upon the national industrial advisory committee (IAC) to designate regions for the dissemination project's focus. (These regions are listed in Table E-1:)

TABLE E-1

Seven target regions, in order of priority, as designated by the Industrial Advisory Committee.

1. Florida.
2. Southern California.
3. New England/Upper New York.
4. Midwest/North Central Plains.
5. New Jersey/Long Island.
6. Washington, D. C.
7. New Mexico/Colorado.

Both the disseminator and the IAC had hoped to catalyze workforce surveys in all seven regions. From the start, however, they planned to initiate educator-employer meetings in only four regions due to the limited time and resources of the project. Also they planned to have the regional meetings precede the surveys, and to rely heavily upon the disseminator's staff and IAC members to organize the meetings.

At the first IAC meeting, Southern California and the North Central U. S. were selected as targets for regional meetings because North Central Technical Institute and Pasadena City College had already expressed interest in helping to host the meetings. The other two regional meetings were to emerge from the letters written to the sixteen state Directors of Vocational Education and from discussions with contacts of the disseminator's staff and the IAC members. The Directors of Vocational Education in Florida and New Jersey responded positively, and agreed to host joint educator-employer meetings in their states.

From the negative reactions of most of the states, the disseminator's staff soon concluded that regional surveys probably should precede regional educator-employer meetings rather than following them (with a survey in hand, many more schools would be attracted to the regional meetings); therefore, regional workforce surveys are presented before regional educator-employer meetings.

II. Implement educator-employer meetings.

The disseminator's staff attempted to make only minimum inputs into the regional educator-employer meetings as necessary for them to be effective. Responsibility for the meetings were left - insofar as possible - to the hosts. Before each meeting, disseminator inputs included lists of possible educators and employers to be invited to the meeting, and assistance in planning the meeting agenda. Early in each meetings, the dissemination project director, Dan Hull, made a presentation on laser applications. But as soon as he had catalyzed interactions between the educators and employers at a meeting, Hull became an observer.

The first regional meeting was held at North Central Technical Institute in Wausau, Wisconsin, on January 30, 1976. The NCTI Assistant Director for Instructional Services, Charles Christianson, moderated the meeting, which was arranged with assistance from Jim Johnson. Johnson, on sabbatical leave from NCTI, was working with TERC-SW (the disseminator).

This meeting was attended by eighteen people, including eleven faculty members and administrators from NCTI, John Ready from Honeywell Research Center (a project IAC member), four people from A. Ward Ford Memorial Institution (a medical research group employing lasers), and a Wisconsin Education Department official. No other school or employer personnel were invited because Hull and Johnson wanted to try their first regional meeting with a coordinated group. After Hull's presentation on lasers and laser applications, Ready talked about LEOT workforce needs nationally and in the North Central U. S. region. The Research Director of the Memorial Institution, Myron Muckerheide, then discussed medical applications of the laser. Near the conclusion of the meeting, LEOT instructional modules were discussed, as was the best approach for NCTI to take in developing a LEOT program. (Detailed accounts of the NCTI, New Jersey, and Southern California meetings were given in a May, 1976, Interim Report.)

The New Jersey and Long Island regional educator-employer meeting was subsidized by the dissemination project and held at the Occupational Resource Center in Edison, New Jersey, on March 23, 1976. This meeting was hosted by Joseph Kelley, Director of Occupational Research and Development Programs for the New Jersey Department of Education. On September 18, 1975, a letter had been sent to Kelley's supervisor, Stephen Poliachic, State Director of Vocational Education, and he had passed the letter on to Kelley, who in turn worked with the project's staff to publicize the new technology. Kelley sent letters describing LEOT to 35 vocational-technical schools. Ten schools responded with requests for sample LEOT Modules. These schools were invited to a regional educator-employer meeting. Several post-secondary institutions that had shown an interest in LEOT education were invited also, along with several employers.

Nine vocational-technical schools said they would come to the meeting and four actually did; four post-secondary institutions accepted the invitation and two came (Camden County College from Balckwood, New Jersey and New York City Community College). Four employers were represented: IBM Corporation (James Smith from the project's IAC), Airtron, Western Electric Corporation, and the U. S. Bureau of Radiological Health. After morning presentations regarding the new technology and regional employment needs, representatives from each of the six schools talked about their interest in LEOT. The need for a regional workforce survey and the best type of program for the region were the last items on the agenda. By the end of the meeting, it was clear that the region's first educational program in the new technology should be based in a post-secondary institution, and that Camden County College was ready to take the lead in starting the program. The employers agreed to assist the College, and the other schools volunteered to observe the program to determine if and when a second program may be needed in the region.

The Southern California meeting was hosted by S. Donald Sims, President of KORAD in Santa Monica and a member of the project's IAC. Arrangements for the meeting were made by another IAC member, D. C. Winburn from Los Alamos Scientific Laboratories in New Mexico, and by Vernon Spaulding, a program developer for Pasadena City College. This April 9, 1976, meeting was attended by twenty-six people, representing fifteen colleges and six employers. The meeting followed an agenda similar to the New Jersey meeting except that it included a report by Vernon Spaulding of Pasadena City College on the Southern California workforce survey. As with Camden County College, the obvious and strong interest of Pasadena City College made it the top candidate among the fifteen colleges to initiate the region's first LEOT educational program; however, several other schools displayed a keen interest.

The final regional educator-employer meeting was held in Orlando, Florida, on May 27, 1976. This meeting resulted from the strong interest shown by the Florida Director of Industrial Education, Talmadge Rushing. Rushing contacted Jim Johnson (of TERC-SW) to learn where within Florida the LEOT workforce need was concentrated, and the two of them initiated a workforce survey which went out on Rushing's letterhead. This letter to 39 employers produced an outstanding 64-percent response rate. Since the workforce need was heaviest in Orlando, Rushing arranged for a meeting there and invited 65 schools. The meeting was attended by ten schools and three firms; nine officials from the Florida Department of Education also attended. Because the Department had funds to subsidize the establishment of LEOT program in one school, no school volunteered its own funds for development purposes. The Department then sent Donald L. Silberman, one of its five program development Consultants, to TERC-SW and TSTI at Waco in June, 1976, to further investigate the nature and prospects of education in the new technology. After deciding to subsidize a new LEOT program, the Department asked Dan Hull

to visit several possible schools and help select one for program development. The Lewis M. Lively Vocational Technical Center in Tallahassee, Florida, was selected for its strong interest, despite not being located in the high-employment Orlando area.

III. Identify key contacts (to further program development).

As evidenced in the preceding discussions of regional educator-employer meetings, certain individuals and institutions emerged as key contacts, willing to actively promote LEOT educational programs within their regions. For the North Central Region, Jim Johnson of NCTI was the key person. Vernon Spaulding of Pasadena City College and D. C. Winburn of Los Alamos Scientific Laboratories have continued to work the Southern California area. And Donald Silverman of the Florida Department of Education has remained involved in Florida. Other individuals with strong interests in LEOT education also were identified during the meetings and the surveys. These individuals, along with the key contacts, form a core group of potential participants in later regional educator-employer meetings and other efforts to facilitate interaction among employers and educators in the new technology. (These key contacts could also serve as disseminators for their regions in a manner analogous to the dissemination strategy employed by TERC-SW during the dissemination project.) Currently there is little interest on the part of most educators within each region in having additional regional meetings. For the most part, subsequent interaction must take place between educators and the disseminator.

The immediate challenge, to develop one outstanding LEOT educational program within each region, might inspire other educators within each region to initiate LEOT programs.

NEW EDUCATIONAL PROGRAMS

I. Identify target schools to initiate new programs.

The dissemination project used a wide variety of means to publicize the need for LEOT educational programs the the existence of a disseminator to assist schools establishing new programs. More than one-hundred fifty vocational-technical schools and post-secondary institutions were contacted directly in the following ways:

35 schools invited by mail to the New Jersey regional meeting (4 attended).

47 schools invited by mail to Southern California regional meeting (14 attended).

65 schools invited by mail to the Florida regional meeting (10 attended).

17 schools briefed at a Maryland meeting.

17 schools reached through contacts of IAC members
and TERC-SW trustees or staff.

2 State Directors of Vocational Education forwarded
the disseminator's letter to one school each.

In addition, many more schools learned about the need and the dissemination project by means of general publicity through journal articles, exhibits or conferences, and work-of-mouth from other occupational educators. At least 25 schools that learned about the dissemination project through these indirect means contacted the disseminator to get more information. From among all of the schools that hear about the project, LEOT programs to be targeted for further contact by the disseminator. These schools, and the means by which they first hear about the project, are listed in Table E-2.

TABLE E-2

SCHOOLS EXPRESSING SUFFICIENT LEOT INTEREST
TO BE TARGETED
(Also gives means by which school first hear of the
LEOT project.)

Albuquerque Technical Vocational Institute - through
Technical Educational Reporter.

Ball State University in Indiana - through Hands-on
newsletter of TERC-NE.

California State Polytechnic University - probably
through conference of professional or trade
society.

Camden County College - called USOE after reading
magazine article on lasers.

Capital Institute of Technology in Maryland - through
conference of society.

Corning Community College in New York - through phone
call from IAC member.

Genesee Community College in New York - through phone call from IAC member.

Grossmont College in California - through Southern California regional meeting.

Highlands University in New Mexico - through contact from IAC member.

Lewis M. Lively Vocational Technical Center - through Florida regional meeting.

New York City Community College - through contact of TERC's EMT Project.

North Central Technical Institute in Wisconsin - through 1973 LEOT mass mailing.

Northeastern University in Massachusetts - through professional journal article

Ontario Science Center - through professional journal article.

Palomar Community College in California - through Southern California regional meeting.

Pasadena City College in California - through professional society conference.

Rochester Institute of Technology in New York - through contacts from IAC member.

San Francisco City College - through contacts of TERC's EMT Project

Springfield Technical Community College in Massachusetts - through TERC's trustees.

State University of New York at Morrisville - through general publicity.

University of Albuquerque - through colleague of an IAC member.

University of Houston at Clear Lake City - general awareness of TERC's work in emerging technologies leads faculty member to contact TERC-SW.

University of Lowell in Massachusetts - through contacts by TERC trustee.

University of New Mexico - Northern Branch - through contacts of an IAC member.

Vincennes University in Indiana - through efforts of an IAC member.

Raymond Walters College, University of Cincinnati, in Ohio - through efforts of an IAC member.

Wentworth Technical Institute in Massachusetts - through contacts by TERC trustees.

It is noteworthy that no single approach to publicizing the program reached a large proportion of the target schools. But of more significance, every approach tried reached someone. Even if the schools that actually implemented courses or programs selected for special examination, it appears that no single approach is much more productive than another; therefore, experience of the dissemination project points to the need for a variety of publicity means.

The project staff found that some educators "talked a big line" but produced little, while others talked little but started a program.

Once contact is made between a school and the disseminator, there also is a need for resources to follow-up on the lead.

11. Plan new courses and programs.

The disseminator offered to assist those schools listed in Table E-2 in several ways:

Listings of employers in the region.

Listings of equipment suppliers.

Samples of LEOT instructional materials.

Liaison with potential advisory committee members.

Liaison with existing educational programs.

Furthermore, the disseminator's staff was available for consultation on program planning and implementation.

The twenty-seven schools responded to these offers of assistance in a variety of ways. Eight schools will have implemented LEOT options or programs by the Fall of 1977, and two additional schools are implementing LEOT courses. Of the remaining seventeen institutions, a few have lost interest, while others are at some stage in the process preceding formal approval of a course or program.

Four of these seventeen schools appear to have lacked a faculty member or administrator who was really committed to planning a LEOT program. Apparently, whoever first made contact with the disseminator disappeared from the scene. Follow-up calls to these institutions indicate that some interest remains in LEOT education, but no action is underway to develop plans.

In two other cases, interested educators did wish to begin planning but were stopped by their schools' lack of financial resources for any new programs.

Another school sent one faculty member to an LIA short course, but has done nothing more. Potential innovators in two additional schools have given up momentarily because of all steps involved in developing a proposal for a new program and getting the proposal approved.

Two institutions with an overwhelming emphasis on liberal arts eventually decided that they were inappropriate bases for LEOT education. One of these schools gave a successful one-evening presentation on holograms, but then decided the school lacked the faculty and laboratory resources for a course on laser/electro-optics. In the other institution, a faculty member in the physics department became very interested in LEOT, attended an LIA short course, developed a tentative program proposal acceptable to the school, obtained the disseminator's assistance in recruiting an advisory committee of employers, only to have the advisory committee reject the tentative curriculum plan because it had too many liberal arts courses and too few courses with an emphasis on laboratory work and hands-on experience. After some additional consideration, the school decided to discontinue the planning effort rather than change its established approach to education.

Faculty members committee to LEOT education did make substantial efforts to develop LEOT programs in five occupationally oriented institutions. One of these individuals used the LEOT modules in a course he taught and visited a school with an ongoing program, but then he left the school where he was based.

In yet another case, the potential innovator visited the pilot LEOT program at Texas State Technical Institute and did considerable planning; he also arranged for one of the disseminator project's staff to visit his school, but was promoted to another position and could find no one to carry on his planning efforts.

The remaining three potential innovators not only interacted extensively with the dissemination project through IAC members and LIA short courses, but also developed and submitted proposals for comprehensive AS-degree LEOT programs. All three proposals were rejected or shelved, however, because the schools lacked financial resources to start programs. Recently, one of the three potential innovators submitted his proposal to another school and is awaiting its rejection or approval.

The last of these seventeen schools showed some interest in LEOT education early in the dissemination project but has moved very slowly toward a program. Currently, the school is planning the details of a course to be offered next year, and has asked an IAC member to react to the course plans.

III. Implement new courses and programs.

Between January, 1975, and May, 1977, ten educational institutions obtained approval for plans to implement LEOT courses, options, or programs. These schools are at various stages in actually implementing these plans.

Ball State University (Muncie, Indiana) first heard about the LEOT disseminator from the Hands-On newsletter published by TERC-NE's Curriculum Development Laboratory in December, 1976. The following month, Ball State ordered Course 1 of the LEOT modules, and a month later, invited the dissemination project director to give a colloquium on laser/electro-optics technology to the physics and astronomy faculty of the University. A faculty group, headed by Malcolm Hultz, then planned and obtained approval for a LEOT course (which will be offered by the physics department in the Spring of 1978) using some LEOT modules. Because Ball State is primarily a liberal arts institution, the faculty has no plans to initiate an entire LEOT program, which would require an elaborate approval process; however, if the first LEOT course proves popular, other courses in the new technology may be tried.

Camden County College (Blackwood, New Jersey) first became interested in the LEOT field when Leonard Hilder, Coordinator of Engineering Technologies, read an article describing practical applications of lasers for the readers of a general interest magazine. Hilder guessed that there must be a need for technical education in the expanding field and had his assistant, Judy Sheridan, contact some leading technical educators in the eastern part of the U.S. to see if any LEOT courses or programs existed. A call to the U. S. Office of Education resulted in a contact with TERC-SW (disseminator) during January of 1976. TERC-SW invited Camden County College to the New Jersey regional educator-employer meeting. Since it was evident that Camden County College was committed to establishing a LEOT program, employers and educators from other schools at the meeting encouraged the College to develop a program.

To document the need for LEO technicians, Hilder next directed a regional workforce survey and then developed a proposal for a LEOT educational program. One of the College's faculty members, Frederick Seeber, attended a LIA short course during this planning period to begin learning the new technology. Further, the College recruited Jim Smith (from IBM) who was the dissemination project's IAC, and Dan Hull (from TERC-SW) to serve on its local industrial advisory committee. During January, 1977, the New Jersey Board of Higher Education approved a proposal for a comprehensive LEOT program after one of the Board's members, the President of Bell Telephone Laboratories, praised the proposal and spoke of the need for many LEO technicians. Two months later, Hull made a trip to the College to assist with detailed program planning. The College has had difficulty finding a coordinator to head the new program because people who combined a master's degree with LEOT expertise require salaries higher than the College can afford to pay. For the moment, this obstacle has been overcome, with Hilder acting as coordinator and by using faculty already at the College until LEOT experts can be recruited.

More than twenty-four prospective students have already signed up for the new program, with forty or more expected by final registration, which would allow the College to create two sessions of the new program.

Lewis M. Lively Vocational Technical Center (Tallahassee, Florida) first heard about LEOT education when the Florida Department of Education invited the school to the May, 1976, Florida regional educator-employer meeting. As already mentioned, TERC-SW assisted with the regional meeting and Dan Hull helped the Department of Education select Lively as the school most likely to establish an effective LEOT program. Texas State Technical Institute of Waco helped by sending Lively a list of all its graduates and their jobs. Later, in March, 1977, Lively received technical assistance from Jim Johnson, who made a consulting trip to Lively from North Central Technical Institute in Wisconsin. Also, a member of the national IAC, David E. Flinchbaugh, serves as a member of Lively's IAC.

During the Spring of 1977, the head of the new program attended two LIA short courses and visited TSTI. Other faculty members planned to attend LIA short courses during the summer of 1977.

The Lively LEOT program, which will admit its first students in September 1977, will be more vocationally-oriented than the LEOT model curriculum because Lively is an open-enrollment institution.

North Central Technical Institute (Wausau, Wisconsin), first heard about the TERC-SW activities in the LEOT field by means of a mailing to 2200 schools in September, 1973. At about that same time, James R. Johnson, an NCTI physics instructor, began exploring ways to develop a course in laser technology. He even obtained a tentative commitment for assistance from the laser research program at the Wausau Medical Center; however, when he asked NCTI administration to go forward with curriculum development plans, Johnson was informed of TERC-

SW activities and asked to investigate the LEOT modules and Curriculum Guide prepared by TERC-SW before continuing on his own. After seeing the TERC-SW materials in the spring and summer of 1974, Johnson decided he was well-prepared to head such a program. Johnson sought NCTI's support to gain additional knowledge and experience in the new technology. A sabbatical leave, arranged for June 1975 through May 1976 (during which time NCTI paid 70 percent of Johnson's salary and TERC-SW paid 30 percent), allowed Johnson to spend the year improving the LEOT modules, visiting schools with programs, and teaching laser fundamentals in some of the LIA short courses. He also helped organize regional LEOT educator-employer meetings, including the one at NCTI.

Initial indications from the Wisconsin Board of Vocational, Technical and Adult Education suggested that a proposal for a comprehensive LEOT program at NCTI would be rejected; therefore Johnson initiated only one LEOT course in the NCTI physics department during each semester of the 1976-77 school year. He also offered a "Lasers in Construction" short course and held an eight-session, noncredit evening course for anyone in the community who was interested in the new technology. In May, 1977, NCTI convinced the Wisconsin Board to approve a proposal for a comprehensive AS-degree LEOT program. This program will begin in September, 1978, after facilities are constructed, which include a 4700 square-foot addition to the NCTI Technical Center. Meanwhile, during 1977-78, Johnson will offer three elective LEOT courses and twice give the eight-session evening program.

Pasadena City College (Pasadena, California) first heard about the LEOT Dissemination Project when Lawrence A. Johannsen, Chairman of the Department of Engineering and Technology, attended the November, 1975, Electro-Optics Systems Design Conference in Anaheim, California, and talked with D. C. Winburn (from the project's IAC). Returning to the College, Johannsen asked Vernon Spaulding in the Office of Occupational Education to explore development of a LEOT program. As mentioned, Spaulding worked with Winburn to develop a regional workforce survey and pull together the Southern California educator-employer meeting of April, 1976.

Xerox Electro-Optical Systems (Pasadena) sent a representative, L. M. Balin, to the meeting, and Spaulding targeted the firm as a logical employer to involve in a LEOT program. By coincidence, another Xerox employee, Wai-Min Liu, Sr., a senior optical engineer, who had taken the LIA's San Diego PAC in October, 1975, discovered the LEOT modules there. Wai-Min Liu had become interested in teaching in the new field. Thus, shortly after the regional meeting, Liu contacted Spaulding and the two began planning an LEOT program.

In May, 1976, Liu took an LIA short courses, and Spaulding visited DeLeone's LEOT program at San Jose City College. Assisted by Donald

Sims and Winburn (from the project's IAC), Spaulding pulled together a local IAC. Meanwhile, in February, 1977, Liu began teaching an introductory LEOT course. He will teach a second course in September, and is planning three additional courses for later if demand for them holds.

Springfield Technical Community College (Springfield, Massachusetts) first heard about the LEOT project because the president of STCC was a trustee of TERC. Shortly before the president retired, he asked an assistant to begin planning a LEOT program; a proposal was approved early in 1975, under the new president. Due to lack of strong faculty commitment to the new technology, however, the program was not implemented immediately - beginning in September, 1977, a LEOT option to the electronics program will be offered at STCC.

University of Houston (Clear Lake City, Texas, campus) first learned about the project because Charles McKay, a member of the University's engineering faculty had been following TERC's activities since he came into contact with TERC-SW through the Electro-Mechanical Technology Project. In January, 1975, McKay began a BS-degree program in Electro-Optics because the University wanted to prepare graduates for employment in high-technology fields that could add to Houston's future economic growth. Eighteen months later, McKay started an MS-degree program in Electro-Optics for the same reason. Because the Clear Lake City branch of the University does not admit students until their junior year, McKay's program now has approximately fifty undergraduates and eight graduate students with previous education in science and technology relevant to laser/electro-optics. Consequently, McKay uses the LEOT modules only for introductory work in his theory or laboratory courses to give less well prepared students a knowledge and skill base more in line with the better prepared students. Six students graduated from the BS-degree program in May, 1977, and fifteen more will graduate during the next school year. (A more detailed description of the Houston BS-degree program is given in the May, 1976, Interim Report.)

University of New Mexico - Northern Branch (Los Alamos, New Mexico) was contacted during the spring of 1975 by D. C. Winburn (the project's IAC) from Los Alamos Scientific Laboratories. He arranged for a laser scientist from the Laboratories to teach an introductory LEOT course at the University during the fall semesters of 1975 and 1976. Los Alamos Scientific shared some laboratory equipment with the two courses and one on optics in the spring of 1977. Some LEOT modules also were included as supplementary instructional materials. Meanwhile, Winburn was shepherding a proposal for a comprehensive AS-degree LEOT program through the University's approval process. With Winburn heading its local advisory committee, the new program is admitting its first students in September, 1977.

Vincennes University (Vincennes, Indiana) discovered the LEOT materials through the efforts of Anita King, Administrative Assistant to the Associate

Dean for Occupational Education. As part of her job, King regularly perused various magazines looking for new technologies for the University to enter. In the General Motors magazine, The Changing Challenge (fall, 1974), she read an article titled, "From Lab to Living-room, Lasers Make their Move," which convinced her that the new technology had advanced to a stage in which it would need technician education. The article mentioned several General Motor Metals employees working with lasers, including Victor Gregson from the General Motors Metals Engineering Department.

In response to a letter from King, Gregson suggested she contact David Edmunds, president of LIA (and an IAC member), Dan Hull of TERC-SW, and John Pierson of TSTI in Waco. She contacted Edmunds, who referred her to Hull, who in turn referred her to James Rockwell, a member of the IAC. Assisted by Rockwell (who then taught at the University of Cincinnati), the Chairman of the Vincennes Electronics Technology Department, Dean Evary, designed a LEOT option for their AS-degree program in electronics. To prepare for teaching the option, Evary and another faculty member attended the LIA "Introduction to Lasers" short course during July, 1975.

Shortly after the LEOT option began at Vincennes University in September, 1975, Herbert Deigl arrived to take over the LEOT instruction. A BET-degree graduate from the LOET program at TSTI (Waco), Deigl almost immediately expanded the number of LEOT courses during the 1975-1976 school year from three to five. Since the option had attracted not only electronics students, but also students from several other technologies, Deigl soon documented the need for a LEOT program separate from electronics. (Some students who wanted to study laser/electro-optics dropped out of the option because they were required to take electronics courses which they viewed as irrelevant.)

During the next school year, Deigl expanded the LEOT offerings to seven courses and submitted a formal proposal for an independent LEOT program. The LEOT option also graduated its first five students in May, 1977. Two of these graduates have gone on to four-year programs and a third is getting an AS-degree in another technology, while the remaining two have had many job offers from firms located outside Indiana. When Deigl's comprehensive LEOT program is approved, it will include nine or ten LEOT courses and will require a second faculty member specialized in the new technology.

Wentworth Technical Institute (Boston, Massachusetts) was approached by the dissemination project director, Dan Hull, and a TERC trustee, Edward Van Dusen, during the spring of 1975. Although the Wentworth faculty and administrators did not respond with enough enthusiasm to begin planning a LEOT course or program, they did begin following workforce needs in the new technology. By the spring of 1977,

the administration and electrical engineering faculty became sufficiently interested to plan a course titled "Electro-Magnetism, Optics and Lasers." This course, which begins in September, 1977, is targeted on third- and fourth-year students from electrical and mechanical engineering. An electrical engineering faculty member, Domenic Pepe, attended a LIA short course in Boston during June, and is being assisted with course planning by David Whitehouse (the project's IAC) from Raytheon Company. If the new course is popular, the Wentworth faculty plans to expand its thrust in laser/electro-optics and will consider initiating a LEOT program.

APPENDIX F
Example Correspondence

**Education
Research
Centers**

Southwest Center

103 Airline Drive, P. O. Box 4395, Waco, Texas 76705
Telephone 817-799-0203

September 18, 1975

Mr. Joe D. Mills
Director of Vocational Education
Florida Department of Education
204 Knott Building
Tallahassee, Florida 32304

ORIGINAL

Dear Mr. Mills:

Technical Education Research Centers (TERC) is an independent, non-profit, public service corporation dedicated to the improvement of occupational and technical education throughout the United States. TERC operates a number of research and development programs sponsored by federal, state, and local agencies, as well as by industry. In its programs, TERC analyzes the job market for a particular type of technician and, with the aid of Industrial Advisory Committees, determines what the technician needs to know to perform his job. Over the past five years, TERC has developed such a program in Laser/Electro-Optics Technology (LEOT) under a grant from the U. S. Office of Education.

A National Advisory Committee consisting of employers of laser technicians volunteered time to participate in the Task Analysis and to give advice in the LEOT program development. This committee has identified a realistic need for technicians in your region and can justify the establishment and continuation of an educational program for preparing Laser/Electro-Optics technicians.

It has been determined that, to guarantee success of proposed programs, it is necessary to coordinate the schools desiring to offer such instruction and the potential employers of the graduates. This coordination is necessary to insure that the design of the new program is such that the employment needs of the local region will be satisfied and that the new technicians can be employed in the career for which they have been prepared.

In its role as a catalyst in the development of technical education programs, TERC is willing to assist in the formulation and establishment of a Laser/Electro-Optics program in your area. We are prepared to sponsor regional planning meetings between representatives of schools and representatives of potential employers.

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A non-profit
public service
corporation

TERC Headquarters:
44A Brattle Street
Cambridge, Mass. 02138

TERC Offices in:
Los Angeles, California • Milwaukee, Wisconsin • Springfield, Massachusetts
Stillwater, Oklahoma • Urbana, Illinois • Waco, Texas • Washington, D. C.

Mr. Joe D. Mills

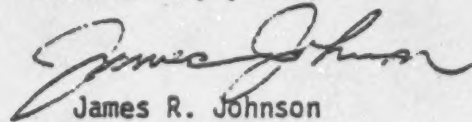
-2- September 18, 1975

Your support and assistance in this venture would be greatly appreciated. We need your help to identify schools in your state that are capable of offering, and interested in developing, a locally designed program to meet this employment need.

For your further information, I am enclosing a Curriculum Guide which not only describes a model two-year LEOT program, but also suggests possible options to existing technical programs.

Thanking you in advance for your assistance, I am

Sincerely yours,



James R. Johnson
Research Associate

JRJ/cr

Enclosure

F-2

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TECHNICAL EDUCATION RESEARCH CENTER - Southwest

4301 Lake Shore Drive, Suite 111

Waco, Texas 76710

Telephone 817-772-8756

18 September 1975

Mr. Joe D. Mills
Director of Vocational Education
Florida Department of Education
204 Knott Building
Tallahassee, Florida 32304

REVISION

Dear Mr. Mills:

Under a project sponsored by the HEW Office of Education, a national advisory committee made up of employers of laser technicians identified a real need for trained technicians in your national region. Their needs assessment survey developed justification for the establishment and continuation of an education program designed to prepare laser/electro-optics technicians in your area to meet entry-level employment requirements. The enclosed document identifies members of that advisory committee, which includes Mr. Carl Bailey, Jr. and Dr. David E. Flinchbaugh, both of Orlando, both employers of laser technicians and both members of the Laser Institute of America.

The enclosed document also describes a flexible, relevant, job-oriented and valid curriculum for training laser/electro-optics technicians, as well as curriculum options for other technicians and professionals who require specific or limited knowledge and skills in laser technology. This material, also developed under Office of Education contract, by laser/electro-optics experts, was carefully monitored and reviewed throughout its development by the advisory committee of employers. Further, it has undergone successful field testing at Texas State Technical Institute (Waco) - all its graduates received several job offers, and those accepting received stipends well above the national entry-level average for associate-degree technicians.

To insure such success, however, there must be coordination between those schools preparing to offer such instruction and the potential employers of their graduates. Coordination insures that the program is designed to graduate technicians who meet local or regional needs and can, therefore, be employed in the career for which they have prepared themselves.

continued---

Mr. Joe D. Mills
18 September 1975
Page 2

In its role as a "catalyst" in the development of technical education programs, TERC (whose nonprofit charter appears on the inside back cover of the enclosed Guide) would like to assist in the formulation and establishment of a laser/electro-optics program in your state. TERC is prepared to sponsor regional planning meetings between representatives of schools and representatives of employers. Your help is especially needed to identify schools in your state that are capable of offering, and interested in developing, a locally designed program to meet this workforce need.

Thank you for your time and for your assistance. This letter, naturally, can not answer all questions. Please feel free to call the undersigned (collect) at your convenience. In any event, in about two weeks we would like to give you a call and explore with you the possibilities of implementing a program in Florida.

Very truly yours,

James R. Johnson
Research Associate

JRJ:cr

Enclosure: Curriculum Guide,
Laser/Electro-Optics.

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APPENDIX G

"LEOT Modules / Ways and Means"

Adaptability Through Modular Instructional Materials

Laser/Electro-Optics Technology requires flexible teaching materials for diverse educational options. The author introduces lasers, LEOT modules, and six differing educational programs.

Daniel M. Hull received his BS from the University of Texas and his MS in Electrical Engineering from the University of Pittsburgh. He has thirteen years of experience as an engineer and manager of laser development and application at Lockheed, Sandia Corporation, and Westinghouse. Mr. Hull is now manager of the Laser/Electro-Optics Technology Program at Technical Education Research Centers/Southwest in Waco, Texas.

The use of lasers spread rapidly after the first one was made operational in 1960. As a result, a demand emerged for a new kind of specialist—the laser/electro-optics technician. Responding to this need, the U.S. Office of Education gave Technical Education Research Centers (TERC) a grant for a project to analyze the new occupation and to develop a curriculum and instructional materials for it.

By means of an occupational analysis, the project confirmed that a variety of technicians were working with lasers. These technicians frequently were involved with other kinds of electro-optical systems as well. Moreover, the project found that not only technicians, but also engineers and other professionals were seeking a better understanding of the hardware and laboratory practices associated with lasers. Although there were certain tasks performed by almost all of these personnel concerned with lasers, many other activities were common to only a few

places of employment.

To take account of the diversity of personnel and tasks, educational programs in this new field had to vary significantly in character and content. Two-year programs in laser/electro-optics technology (LEOT) were an evident need, for example, and so were laser options within existing programs in Vacuum and Glassblowing Technology and in Electronics. Furthermore, laboratory laser courses were attractive potential additions to baccalaureate and graduate level studies in physics and engineering. Also needed were short courses and industrial in-house training programs with laser information for employed technicians and professionals.

The challenge faced by the LEOT curriculum developers was to devise instructional materials for use in all these settings. To be adaptable to such a diversity of learning environments, the materials had to be both *flexible* and *valid*.

WHAT ARE LASERS

The laser is a device which converts electrical power into a special beam of light power. This beam results from "Light Amplification by Stimulated Emission of Radiation," or LASER. A laser beam differs from ordinary light in several ways:

- It is directional and collimated so that it spreads very little as it propagates through space. For example, a laser beam transmitted from the earth illuminates an area on the moon less than two miles in diameter. Since the beam diffuses so little, the intensity within the beam remains high.
- Its light waves do not vary significantly in length. Therefore, laser light has the purest color of any light source known to man.
- Its light waves are "in phase," so laser communications systems can transmit many wide-band signals with minimal interference problems.
- Its energy can be concentrated into an extremely short duration pulse to produce tremendously high bursts of light power. This power can cause explosive effects by rapidly heating materials to several million degrees.

Various types of lasers are in use, differing in their construction and methods of operation. They have output wavelengths ranging from the ultraviolet to the visible region and extending to the far infrared. Some lasers are small enough to be held in the hand and have an output power less than a flashlight. Other lasers occupy 10,000 square foot buildings and are powerful enough to melt holes through thick metal plates.

As heat sources, lasers are employed in welding or drilling materials and in repairing eye retinas. In surgery or clothing manufacturing, they can serve as precise cutting tools, while they are information transmitters in radar and communication systems. Lasers are also used for aligning objects and measuring distances in such fields as highway construction. Grocery stores and other merchandizing establishments are beginning to experiment with computer-linked lasers which scan the prices of items on automatic check-out counters. Among its many uses, the laser even has a photographic application in non-destructive testing of objects and in art; it can produce a "hologram"—a negative from which a three-dimensional object can be reconstructed.

A MODULAR APPROACH

To assure flexibility, TERC chose a modular approach to curriculum development. Modules are short instructional units with clear and measurable learning objectives. Although short films are sometimes used to convey the unit of information, modules are usually based on booklets. They can include laboratory exercises to provide "hands-on" experience; in fact, laboratory learning can be the key element of each module, as in the LEOT modules developed by the project.

Typically, modules begin with a statement of the topic to be covered, then present the information, and conclude with questions to test the student's understanding of the material. No previous knowledge is assumed in most modules. They are independent units which might be arranged and rearranged to produce a great variety of courses.

If the modules are valid, they effectively and efficiently teach the student what he or she needs to know to be able to work competently in a remun-

erative and satisfying job. Not only must the materials foster learning, but they must also have *relevant* content. They must present information which reflects what employers want their technicians to know and be able to do.

In the case of TERC's LEOT Project, a national Industrial Advisory Committee consisting of sixteen members identified the duties normally expected of technicians working with lasers. An occupational survey confirmed these duties and continued guidance from the Advisory Committee ensures current validity.

The duties of the Laser/Electro-Optics technician are many. They construct systems in which the laser is an important component and keep lasers clean, aligned and calibrated. They also select and purchase LEOT hardware, including such specialized instruments as interferometers and spectrophotometers. In addition, the LEO technician must have considerable expertise in operating laser systems and performing exacting tests and measurements. Monitoring, troubleshooting and repairing laser systems are among the technician's other responsibilities.

These duties were subsequently broken down into 155 specific tasks for which learning objectives were established. The objectives formed the basis for the subject matter of the modules. A total of 101 modules were carefully developed and grouped into the following ten courses.

- Course #1 Introduction to Lasers (11 modules)
- Course #2 Geometrical Optics (11 modules)
- Course #3 Laser Technology (11 modules)
- Course #4 Experimental Optical Methods (9 modules)
- Course #5 Wave Optics (11 modules)
- Course #6 Laser and Electro-Optics Components (11 modules)
- Course #7 Laser/Electro-Optics Devices (10 modules)
- Course #8 Laser Applications (10 modules)
- Course #9 Laser Projects (7 modules)
- Course #10 Laser/Electro-Optics Measurements (8 modules)
- Plus 2 modules on lab notebooks and measurement accuracy

The technical accuracy of these modules was then checked by members of the Industrial Advisory Committee and by two experienced technical editors. Validity was obtained by incorporating "hands-on" learning experiences which used laboratory equipment typical of that found in the organizations which employ LEO technicians. The effectiveness of these modules was subsequently verified through pre- and post-tests conducted with students in the pilot LEOT program at the Texas State Technical Institute in Waco, Texas.

A two-year Model LEOT Curriculum is being tested at TSTI. However, schools which implement LEOT instructional materials are cautioned that both the Model Curriculum and the LEOT course content are based on broad, national needs, and might not adequately represent local demands. They are accordingly urged to form their own Industrial Advisory Committees for setting educational objectives and choosing the LEOT Modules relevant to their local needs.

OPTIONS

For instance, the LEOT program at San Jose City College is skill-oriented in response to the character of its student body and the needs of local employers. By introducing several groups of LEOT modules into the college's existing program in Vacuum and Glassblowing Technology, it became possible to offer a laser/electro-optics option. The San Jose students can now obtain the skills necessary for various entry-level jobs depending on how much of the two-year program they complete. (This program and the others sketched here are elaborated in the descriptions which follow.)

In contrast, the Technical School of Idaho State University has elected to initiate a Laser/Electro-Optics option in its Electronics Technology Program. It should be emphasized that a complete two-year laser program is not necessary to provide students with LEOT skills useful in the world of work. Employers or research institutions which incorporate a laser or electro-optical device as a component of a larger instrument or system (e.g. transmitter for a radar system) find the laser/electro-optics option in an electronics program to be especially attractive.

Selected LEOT modules can also be included as texts in physics and engineering laboratories. The University of Illinois at Urbana has successfully experimented with this use of the LEOT

modules since last fall. In addition the modules have been used effectively in short courses which attempt to familiarize a wide variety of students with the laser and its many applications. The one-week courses in Introduction to Lasers and in Laser Safety given at the University of Cincinnati are important examples of how the modules can be used to advantage for intensive training.

Employers engaged in training or retraining personnel can also benefit from the modular approach. Current examples of this are the AEC Contractor Laboratories Sandia, Los Alamos, and Lawrence Livermore Labs—where major workforce shifts into the development of high power lasers and the use of lasers for generating electric power have made substantial retraining necessary. The LEOT modules have facilitated this retraining.

LEOT MODULES POINT THE WAY

For over ten years, the laser and electro-optics field has had a shortage of trained technicians. With advent of the LEOT modules, both educational institutions and industry have been provided with teaching options that did not exist before. *The success of the modules has been due to their validity and flexibility, characteristics that have made them adaptable to a number of learning environments. Indeed, the modular approach may be the most effective for all technologies that have a diversity of applications. The use of modules in curriculum development will hopefully extend far beyond the Laser/Electro-Optics field.*

by Daniel M. Hull

Motivated Students Innovate

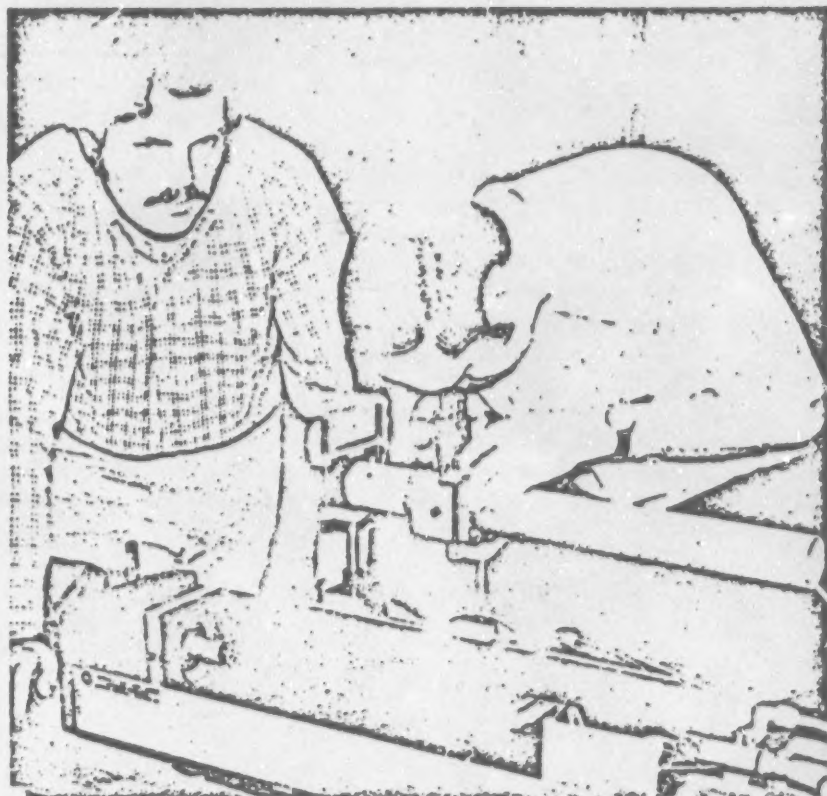
Johnny Jones, Texas State Technical Institute

Johnny Jones holds BS and MS degrees in Physics from Stephen F. Austin State University in Texas. After constructing a HeCd laser system for his thesis project, he joined the Laser Electro-Optics faculty at Texas State Technical Institute in Waco.

The Laser/Electro-Optics Department of the Waco Campus of Texas State Technical Institute (TSTI) first opened its doors to students in 1970. Since that time, the Department has grown to three technical faculty members and over one hundred students. The Department offers a two-year curriculum and an option of two additional years. Fifty graduates are currently employed in the laser and optics industries of ten states. Each two-year graduate has had several job offers with an average starting salary of \$9300 annually.

One of the reasons for the success of the TSTI-Waco program has been the constant scrutiny of its LEOT curriculum. A growing understanding of industrial needs, an increasing availability of text materials, and a willingness to listen to the needs of its students have all contributed to the development of the program.

A chief disadvantage of the original curriculum was that students did not take their first laser course until the third quarter. *Because first-year students had little contact with their major department, many became disenchanted with their major and a high*



Johnny Jones (left) and student

attrition of first-year students resulted. A revised curriculum overcame this difficulty by giving students two laser courses in the first quarter and at least one in each succeeding quarter.

In response to student needs, a survey-orientation course was also initiated. The course presents students with job descriptions and occupational opportunities in laser/electro-optics, and facilitates student adjustment to the TSTI campus.

Another course, "Laser Projects," is a favorite of many students. The course comes at the end of the two-year program and allows students to apply the knowledge and skills they have acquired to individual projects. Most projects involve design, construction, and evaluation of equipment.

The students have constructed a vacuum system for filling gas tubes, a HeCd laser, a ruby laser, a six milliwatt HeNe laser, special filters, special optical mounts and, most notably, a 4 x 8 foot vibration isolation table.

The student-built table saved the LEOT program a considerable expenditure of funds. The table top consists of 2,200 pounds of concrete reinforced with steel, and rests on five legs made of concrete pier blocks. Damping is provided by layers of carpet between the blocks and by an inner-tube on the top of each leg. An air compressor and manifold provide pressure control for the tubes. The entire table was constructed for less than \$150; equivalent commercial tables cost over two thousand dollars.



Making Holograms on a vibration-free table built by students

One of the most important assets of the LEOT Department has always been high student morale. In addition to the building and maintaining of equipment, student participation in classroom presentation clearly contributes to morale and the quality of instruction. Yet perhaps the most important motivational factor is a clearly defined

employment goal. Graduates frequently visit the Department, speaking about their jobs, and members of the Industrial Advisory Committee and other representatives of employers often address the students on trends and opportunities in the field of lasers and electro-optics. Such exposure helps the student develop a realistic view of the career for which he or she is preparing.

By maintaining good relations with industry, the Department has been able to respond rapidly to changing manpower needs, as well as keep abreast of employment opportunities as they become available. An additional dividend has been the donation of equipment from organizations interested in the training of technicians.

The Laser/Electro-Optics Department at TSTI emphasizes job skills. A great deal of practical, hands-on laboratory experience is provided with exposure to as much of the industry as possible. While LEOT modules make up the major portion of most course materials, they cannot train technicians by themselves. They are an important and versatile tool when used in conjunction with other source materials, additional laboratory exercises, special projects, and contacts with industry. The key to a successful program is the maximum utilization of all resources available.

by Johnny Jones

An LEOT Option in Electronics



Richard R. Davis (right) and students

Richard R. Davis, Idaho State University

Richard R. Davis holds a BS and an EdM from Idaho State University. He has performed research in the field of laser communications and is the author of *AP and RF Circuit Approximations*. Mr. Davis is presently at the School of Vocational-Technical Education of Idaho State University.

Idaho State University offers a program in Laser/Electro-Optics technology which draws upon the already existing three year electronic technology curriculum. As an option within the electronics department, the LEOT program attempts to prepare a technician who is proficient in both electronics and laser/electro-optics.

All courses in the LEOT program are taught by faculty members of the Electro-Technologies programs. If a student needs a course in English, math or physics, the course is closely related to his or her total program. This can best be accomplished by faculty members who can approach related subject matter from an electronics, laser and optics standpoint.

Student projects are an important feature of every semester after the first three. Ranging from three to twelve

weeks in length, these projects encourage the development of self-reliant technicians who can also work in teams. Students gain practice in working from engineering notes, in manual skills needed to implement ideas, and in writing final reports. These experiences reinforce theoretical concepts, and introduce students to the kind of work they will be doing on the job.

The demand for technicians who combine a knowledge of LEOT with a sound electronics base far exceeds the supply. This type of graduate is preferred by companies which develop or utilize systems with laser components. Already over 75 companies have indicated an interest in employing the first ISU class of LEOT's.

by Richard R. Davis

Adapting Facilities for Local Needs



John J. DeLeone, San Jose City College

John J. DeLeone has been involved in research and development in electronics, vacuum, plasma, and welding technologies. Before joining the San Jose City College he worked for several engineering firms.

San Jose City College is a two-year institution with no tuition charges and minimal entrance requirements. The school offers local residents a chance to acquire skills that will qualify them for better jobs.

One San Jose program with this objective is Vacuum Technology and Technical Glass Fabrication. The program, which has been operating since 1965, evolved in response to local work force needs. It boasts a well-equipped vacuum laboratory, and a complete facility for glass fabrication.

As the manufacturers of gas lasers became concentrated in the San Francisco Bay area, San Jose City College began investigating the feasibility of a laser technician training program. The school's existing Vacuum and Glassblowing Technology program seemed to offer an excellent base for the envisioned training effort. Vacuum sys-



tems and glassworking facilities are necessary for making, evacuating, filling and sealing gas laser tubes, as well as for growing crystals, coating mirrors, and developing semiconductor integrated circuits.

With the assistance of an Industrial Advisory Committee, an introductory course in laser technology was planned during 1973. In the spring of 1974, thirty-six students registered for the course. The composition of the first class is fairly representative of the student body at San Jose. Many of the course participants were veterans, five were full-time employees of local electronics firms, seven were women and six were physically handicapped.

Although some of the LEOT modules were appropriate for the introductory course, they had to be carefully selected and modified to meet the

course objectives using existing laboratory facilities. Moreover, the majority of students, who entered the course unprepared for much of the theory, had to spend the first semester developing basic mathematic skills. The resulting course utilized some of the modules in LEOT course #1, but substituted glassblowing activities for the more difficult modules.

In general, the skills developed in the introductory course provided the student with the option to continue in the program, to seek another vocation, or to enter the industry as an assembler. Similarly, the expanded laser technology program, scheduled to begin in the spring of 1975, will encourage students to "spin off" and enter industry whenever they feel they are ready.

by John J. DeLeone

Module Use in Continuing Education

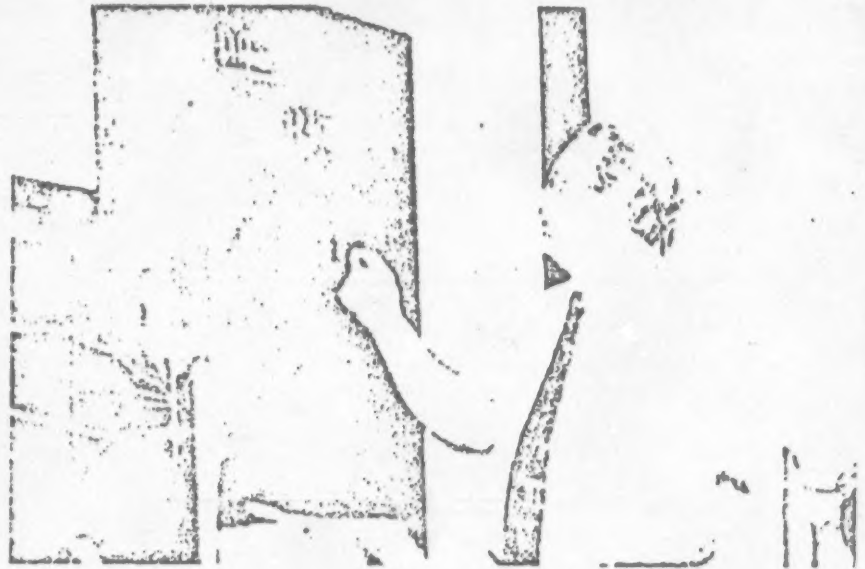
R. James Rockwell, Jr., University of Cincinnati

R. James Rockwell, Jr. received his BS and MS degrees in Physics from the University of Cincinnati. He is Directing Physicist of the Laser Laboratory at the Medical Center of the University and also is the current president of the Laser Institute of America. Mr. Rockwell has published numerous papers and is co-author with Dr. Leon Goldman of the recent book, *Lasers in Medicine*.

Two one-week courses in laser technology are offered as continuing education programs at the University of Cincinnati. These courses provide ongoing training for people who are working in jobs which require some knowledge of lasers and their applications. One of these two courses, "Laser Safety," has been given thirteen times during the last four years, and has been attended by over five hundred students. The average level of educational attainment of these attendees has been approximately four years of college. These students have represented industrial laser research, laboratories, government agencies, corporate or military safety units, and legal and insurance firms, to name only a few.

At its inception, the Laser Safety course was strictly lecture in format. Like most lecture courses, participants were inundated with facts and theories by the second day of the weeklong session. The use of a wide range of visual aids such as slides, films and closed circuit television have enhanced the continually-updated lectures. As the course evolved, however, student desire to have hands-on experience led to the present format, which includes some laboratory "workshop" sessions designed to reinforce the lecture material.

The workshop sessions concentrate



on optical principles, laser measurement, hazard calculation, and control measures. They introduce students to the basic physical concepts of electro-optics and lasers, and then allow them to verify these principles in their laboratory work. In two of these sessions, LEOT modules are now used extensively to provide hands-on experiences with lasers and measurement equipment.

Due to the successful use of these modules in the safety short course, a second short course was planned relying primarily on the LEOT modules. The course, called "Introduction to Lasers," was given for the first time in

July of 1974. Participants in this course included engineers and technicians from industrial and government laboratories using laser-related equipment; and teachers from two-year colleges considering the implementation of LEOT options in their programs.

The success of the modular concept in the continuing education program on laser technology suggests that the approach may be of value in similar programs at other institutions. It may, in fact, be the most appropriate way for orienting professionals from many fields to a specialized technical topic.

by R. James Rockwell, Jr.



LASER SAFETY

This symbol has become the universal signature for a laser beam. The United States requires that all lasers be labeled with this symbol and a safety classification, numbered one through four from least to most dangerous. Lasers range in power from those that can be safely viewed head on to those which can melt steel.

Laser Orientation for Graduate Students

Thomas A. DeTemple, University of Illinois at Urbana

Thomas A. DeTemple received his BS and MS degrees from San Diego State College and his PhD in Electrical Engineering from the University of California at Berkeley. He taught at the University of Arizona before joining the engineering faculty at the University of Illinois.

In 1973 a new laboratory course in Quantum Electronics was initiated in the Department of Electrical Engineering at the University of Illinois at Urbana. The course was developed partly in response to student interest in lasers and partly because the Urbana faculty perceived the need to train students experimentally for research at the graduate level. Twenty students participated in the course during its first year and the number of participants is expected to double this year.

Although the Department had previously offered three textbook courses in lasers both at the baccalaureate and the graduate level, the Quantum Electronics course was the first laboratory course in this subject area. The University of Illinois course also represents the first attempt in the United States to incorporate LEOT modules as a means of providing hands-on experience with lasers to advanced engineering students. The goals of the course are to illustrate the fundamental characteristics of lasers, to develop laboratory techniques, and to impart information regarding the use and misuse of lasers.

To attain these goals, the faculty had to attend to a wide variance in student backgrounds. In addition to an expected enrollment of students from the electro-mechanical disciplines, a significant number of chemistry, mining, and metallurgy students attended the course. There were some



Thomas A. DeTemple (right) with student

individuals who had no background in Quantum Electronics and others who were starting dissertation research in the field, all in the same course!

A partial solution to teaching this range of students was found in the LEOT modules. Since these were geared primarily for use in associate degree programs, they had to be considerably modified for use with advanced engineering students. Much of the material in the modules was incorporated into the laboratory notes as orientation information for experiments. Interestingly enough, even those students with a graduate level knowledge of Quantum Electronics found the inclusion of the modules to be helpful.

In order to quickly familiarize students with lasers, laboratory work begins by requiring students to assemble the equipment they will be using during the course. Coursework then proceeds

to an integrated series of lectures and planned experiments. During the last third of the semester, students initiate individual projects, some of which consist of building important pieces of equipment. This segment of the course is expected to expand considerably as course enrollment grows and a greater amount of materials and equipment becomes available.

The expansion of the course in Quantum Electronics confirms the commitment of the University of Illinois to providing hands-on experience with lasers at the graduate and undergraduate levels. Other engineering schools might consider initiating development of similar programs. If the University of Illinois experience is generally valid, the LEOT modules can be most useful in developing these programs.

by Thomas A. DeTemple

Training LEOTs in Industry

**Raymond M. Dovik, Lawrence
Livermore Laboratories**

Raymond M. Dovik is Electronic Technician Supervisor in the Controlled Thermonuclear Reaction program of Lawrence Livermore Laboratories, where he has been employed for 20 years. He was an electronics technician in the U.S. Navy and holds an AS in Electronics from Diablo Valley College in California.

At Lawrence Livermore Laboratories in Livermore, California, the development of laser-fusion for electrical power plants has been progressing steadily. The objective of the laser-fusion program is to develop a new, safer method of generating electrical energy from atomic power. A problem for the program is the scarcity of well-trained laser technicians.

None of the technical schools in the nearby community graduated highly-trained laser technicians, and very few even offered courses in optics. LLL initially solved this problem by hiring seven LEOTs graduating from Texas



Raymond M. Dovik (right), technician on left.

State Technical Institute. However, the fast-growing demand for this type of specialist at LLL and the availability of technicians without laser training suggested the need for an in-house training program as well.

A one-week exploratory training session held during the summer of 1973 resulted in the partial retraining of fourteen Livermore staff persons. LEOT instructional modules were used in this session. The flexibility of the modules enabled the training staff to choose only the material relevant to the specific objectives of the training session. Due to the success of this initial effort, the training program was expanded during the summer of 1974 to include 27 students. Among these were two electronic engineers engaged in laser research for controlled thermo-

nuclear reactions, while the others were electronic or mechanical technicians.

Much of the success of the training program is due to the cooperation between the Livermore staff and the LEOT staff at TERC and the Texas State Technical Institute in Waco. LLL has received invaluable assistance in implementing the LEOT modules, and TSTI has gained insight into the needs of one potential employer of its graduates. *Such employer-educator cooperation is badly needed in technical education, and the Livermore-TSTI experiment deserves the attention of all those concerned about laser technology, as well as many other technical fields.*

by Raymond M. Dovik